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GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

ANNUAL REPORT

(NEW SERIES)

VOLUME V

PART I

REPORTS A (1890), A (1891), D, E, F, G, L, M

1890-91



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY

1893



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To the Honourable
T. MAYNE DALY, M.P.,
Minister of the Interior.

SIR,—Herewith I have the honour to submit Volume V. (new series) of the Reports of the Geological Survey of Canada.

This volume of 1566 pages consists of 13 separate reports, bound in two parts, with maps and illustrations descriptive of the geology, mineralogy and natural history of the various sections of the Dominion to which the several reports relate. These have been published separately at intervals during the past eighteen months, and can be purchased at prices from ten to twenty-five cents each. Any of the maps published by the Survey can also be purchased on application to the librarian at ten cents each.

Calgary
I have the honour, Sir, to be
Your obedient servant,

ALFRED R. C. SELWYN,
Director.

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GEOLOGICAL SURVEY DEPARTMENT
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1890

BY

THE DIRECTOR



OTTAWA

PRINTED BY S E DAWSON, PRINTER TO THE QUEEN'S MOST
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1893

Technical officers.

Governor in Council may confer designations.

Qualification requisite in certain cases.

Graduates of certain institutions.

Service in Department.

Experience elsewhere.

Objects.

Geology, mines, natural history.

Collections and arrangements thereof.

"*The Civil Service Act*;" and in accordance with and under the terms of section six of the said Act:

2. Such officers of the Department as are continuously engaged in the prosecution of original scientific work or investigation shall be classified as technical officers, under class (b) of Schedule A of "*The Civil Service Act*," and the Governor in Council may cause to be prepared a list of such officers of the Department as are considered to be entitled to be thus classified with any designations that may be deemed expedient to indicate the scientific work in which they may be engaged.

4. No person shall, after the passing of this Act, be appointed to this Department under class (b) of Schedule A of "*The Civil Service Act*," unless—

(a.) He is a Science Graduate of either a Canadian or foreign University or of the Mining School of London or the *Ecole des Mines* of Paris or of some other recognized science school of standing equal to that of the said universities and schools, or a graduate of the Royal Military College, and in each case only after having served a probation of not less than two years in the scientific work of the Department; or unless—

(b.) He has served a probation of not less than five years in the scientific work of the Department; or unless—

(c.) He has had experience for the same number of years in similar work, official or otherwise, elsewhere.

5. The duties, object and purposes of the Department shall be:—

(a.) To make a full and scientific examination and survey of the geological structure, mineralogy, mines and mining resources of Canada and of its fauna and flora;

(b.) To maintain a museum of geological and natural history and to collect, classify and arrange for exhibition in the museum of the Department such specimens as are necessary to afford a complete and exact knowledge of the geology, mineralogy and mining resources of Canada; to collect, study and report on the fauna and flora of Canada; to carry on chemical and palaeontological investigations, and to make such other researches as will best tend to ensure the carrying into effect the objects and purposes of this Act;

(c.) To prepare and publish such maps, plans, sections, Maps, &c. diagrams and drawings as are necessary to illustrate and elucidate the reports of surveys and investigations ;

(d.) To collect and to publish, as soon as may be after Statistics. the close of the calendar year, full statistics of the mineral production and of the mining and metallurgical industry of Canada ; to study the facts relating to water supply, Water supply. both for irrigation and for domestic purposes, and to collect and preserve all available records of artesian and other wells, and of mines and mining works of Canada.

6. The Deputy-Head and Director of the Department Reports. shall, as soon as may be after the close of each calendar year, make a summary report to the Minister, of the proceedings and work of the Department for the year, and shall also furnish final and detailed reports to be issued from time to time in such a manner and form as the Minister directs ; and the Minister shall cause the same to be laid before Parliament, with such remarks, explanations and recommendations as he thinks proper.

7. The Department shall be furnished with such books, instruments and apparatus as are necessary for scientific reference and for the prosecution of the survey ; and the Governor in Council may, from time to time, cause the enlargement of the museum, and the distribution of duplicate specimens to scientific, literary and educational institutions in Canada and other countries, and also the distribution or sale of the publications, maps and other documents issued by the Department.

8. The Minister may, for the purpose of obtaining a basis for the representation of the geological features of any part of Canada, cause such measurements and observations and physiographic, exploratory and reconnaissance surveys to be made as may be necessary for or in connection with the preparation of geological maps, sketches, plans, sections or diagrams.

9. Persons employed in one section of the Department may be directed by the Minister to perform any duty in employees. or with respect to any other section.

10. No person employed in or under the Department shall—

(a.) Purchase any Dominion or Provincial lands except under authority of the Governor in Council ;

To be submitted to Parliament.

Distribution of specimens and publications.

Surveys.

Employees not to deal with public lands.

Nor to disclose information obtained.

Work for individuals
Interest in mines, &c.
Saving.

R.S.C. c. 23,
repealed.

Date of coming into force of Act.

(b.) Locate military or bounty land warrants, or land scrip, or act as agent of any other person in such behalf ;

(c.) Disclose to any person, except his superior officer, any discovery made by him or by any other officer of the Department, or any other information in his possession in relation to matters under the control of the Department or to Dominion or Provincial lands, until such discovery or information has been reported to the Minister of the Interior, and his permission for such disclosure has been obtained ;

(d.) Make investigations or reports relating to the value of the property of individuals, nor hold any pecuniary interest, direct or indirect, in any mine, mineral lands, mining works or timber limits in Canada.

11. Nothing in this Act shall be construed to invalidate or interfere with the commissions, as assistant directors, heretofore issued under Orders in Council to certain members of the scientific staff.

12. This Act shall be substituted for chapter twenty-three of the Revised Statutes, respecting the Geological and Natural History Survey of Canada, which is hereby repealed.

13. The foregoing provisions of this Act shall come into force on the first day of July, one thousand eight hundred and ninety.

Hitherto the Geological Survey has been regarded as a branch, or sub-department of the Department of the Interior ; by the present Act it has been made a separate Department, and while the official designation of the organization has been changed, no change has taken place in its functions or in the duties with which it is charged, as set forth in section 5, subsections *a*, *b*, *c* and *d*, and in section 8. By the provisions of section 4 it is hoped to maintain the efficiency and high scientific standing of the Department, but in order to ensure this desirable result a scale of remuneration should be established in the Department, more in accordance than it is at present with that which obtains elsewhere, and even in other departments of the public service and in the universities of Canada, for acquirements and experience such as is required of the technical officers of the Geological Survey, and in view of the risks, hardships and responsibilities they are often called upon to undertake. It should further be borne in mind in considering this matter that the officers of the Department are strictly prohibited from engaging in the private practice of their profession, for which there

are many opportunities, and by which their incomes could be often largely augmented. As professors in the universities, there are no such restrictions laid on them, while the salaries are larger and the vacations longer. The result is that our best and most capable men seek employment elsewhere. Since July, 1887, four such cases have occurred. Three of these are now university professors with considerably larger salaries than they would have received had they remained on the Geological Survey.

In this connection it may not be out of place to quote the words of a leading article which appeared in the Montreal *Herald* on the 24th of February, 1885, as follows :—

"The field of operations of the Canadian Geological Survey is so vast, the interests involved so great and so far-reaching, the staff provided for the work so weak numerically, that it is important to all the interests at stake that such officers as are called upon to bear the responsibility of the duties of the Survey, should be the best obtainable, and their salaries in keeping with their high attainments."

The truth and applicability of the above remarks cannot be refuted ; they are as pertinent now as they were in 1885, and, therefore, I venture to express a hope that in the consideration of the estimates for the Department for the ensuing year, they will receive due consideration.

The early part of the year now closed was, as usual, occupied by the members of the staff in the preparation of maps and reports, in studying collections gathered during the summer, and in otherwise working out the results of the observations made in the field in 1889. Some of the reports relating to this work have already been published, and others are passing through the press. These will together constitute the Annual Report, Vol. IV., 1888-89, to be issued during the winter.

Those already issued since the 31st December, 1889, are :—

- Part A.—Vol. IV.—1888-89. Summary Report of Operations.
- “ B.—Report on a portion of the West Kootanie District, British Columbia.—Dawson.
- “ E.—Report of Exploration of the Glacial Lake Agassiz, in Manitoba.—Upham.
- “ K.—Report on the Mineral Resources of the Province of Quebec.—Ells.
- “ S.—Report on the Mining and Mineral Statistics of Canada for 1888.—Brumell.
- “ S.—Report on the Mineral Statistics and Mines for 1889.—Ingall.
- “ T.—Annotated List of the Minerals occurring in Canada.—Hoffmann.

Early in April arrangements were made to send out fourteen field parties. Four of these parties worked in two divisions, thus making practically eighteen parties in the field, distributed as follows :—

British Columbia.....	2	Quebec	4
North-west Territories, Atha-		New Brunswick	1
basca District.....	1	Nova Scotia.....	3
Manitoba	2	Labrador	1
Ontario	2		

A brief summary of the operations of these several parties is submitted herewith, as also of the work done in the several divisions of the Department as under :

- | | |
|----------------------------------|--------------------------------|
| 1. Mineral Statistics and Mines. | 6. Topography and Mapping. |
| 2. Chemistry and Mineralogy. | 7. Library. Sale and Distribu- |
| 3. Paleontology and Zoology. | tion of Publications. |
| 4. Botany. | 8. Visitors. |
| 5. Entomology. | 9. Staff, Finances and Corres- |
| | pondence. |

The general progress of the field work has been satisfactory, though the resignation of members of the staff, already referred to, and others having to take up their work, has occasioned considerable delay in completing maps and reports and in the publication of result.

On the 17th of June I left Ottawa for Shelburne, Nova Scotia, to visit the gold fields first opened in 1886 at and near Caledonia Corner, and to investigate the probability of the same leads continuing southward and westward, into the county of Shelburne, and also to ascertain what would be the best plan of operation in commencing a detailed examination and survey of these western parts of Nova Scotia in connection with the occurrence of gold, in quartz veins or in placer deposits, or in regard to other economic minerals. I had, in 1870, visited and cursorily examined the same part of the Nova Scotia coast, having then made detailed notes on a journey from Digby *via* Weymouth, Cape St. Mary and Salmon River to Yarmouth; and thence to Tusket, Shelburne, Liverpool and Bridgewater to Lunenburg, the Ovens and Chester, returning to Bridgewater and Liverpool *via* New Ross and Dalhousie, and from Liverpool to Annapolis *via* Caledonia. The present trip has enabled me to do little more than refresh my memory and to confirm the general accuracy of the conclusions then arrived at respecting the distribution of the granitic and gneissic rocks and the gold-bearing series, as subsequently delineated on the geological map.

On the 23rd of June a trip was made 28 miles up the river from Shelburne to Indian Fields, where some pits have been sunk searching for gold. The country here is tolerably open, much of it flat and swampy and covered with drift and a fine granitic gravel or sand, with few exposures of the underlying rocks, though doubtless such would be

found by following up the beds of all the brooks and small streams in the district. On the 24th of June I examined the route from Shelburne to Lockeport, and thence *via* Sable River, Port Joli and Granite River to Liverpool. On the 25th I drove from Liverpool to Caledonia, 30 miles inland, and found the rocks to be alternations of the "whin" and black slates of the Atlantic coast Gold Series or Lower Cambrian, as indicated on the published geological map. The gold field of Whiteburn, six miles south-west of Caledonia, was visited on the 26th. It is of limited extent, on an oval shaped anticline outcrop of the lower "whin" rock, surrounded by the upper black slate. The veins are parallel with the stratification. They are not more than from six to nine inches thick, and therefore costly to work, as about four feet of hard barren rock has to be mined in driving or sinking on them. Consequently, though the quartz is of more than average richness the profits are not large. The beds dip about 45° to S.E. On the 27th I left Caledonia for Bear River, on the Annapolis Basin. As regards the extension or recurrence of anticlines like those in which the Malaga and Whiteburn leads occur, further to the south-west, no definite statement can be made. That some such areas should be found in the unsettled country where the boundaries of the counties of Digby, Yarmouth, Shelburne, Queen's and Annapolis meet, and especially along the flanks of the central granite mass, the limits of which have not yet been traced, but which certainly occupies a considerable area in this district and which is crossed with a width of ten or twelve miles on the road between Maitland and Bear River, is most probable.

On the 2nd of July I returned to Ottawa, and then made arrangements with Professor Bailey of Fredericton, to commence a detailed examination of the south-eastern coast of Nova Scotia. His summary report of the work done in pursuance of this arrangement is now presented.

On the 11th July, after attending to correspondence and other departmental work, I left Ottawa again for Manitoba, the North-west and British Columbia. Deloraine, Morden and the Lowe Farm were visited in connection with the water supply question. The Turtle Mountain coal field was also examined.

In the summary report for 1889, the well then boring at Deloraine was referred to, and I said: "There seems every probability, when a sufficient depth has been reached, a good supply of artesian water will be obtained." I was at Deloraine on the 22nd of September, 1889, and the boring, then 1,340 feet deep, was progressing, but the available funds were exhausted. On the 29th of October, on my arrival in Ottawa, I recommended that a further special grant should be made

to continue the boring to the required depth, and stated that water might be expected between 1,500 and 1,600 feet. The grant recommended was assented to and in December, 1889, a depth of 1,475 feet had been reached when the contractor reported that he could not go deeper without enlarging the hole. The work incidental to this occupied him several months and in July, 1890, when I again visited Deloraine, I found the hole had been re-bored to only 1,180 or 295 feet less than it was in the previous December. On the 21st of October, 1890, the expected water was struck at a depth of 1,570 feet. It is of fairly good quality and has since stood at about 8 feet from the surface. Unfortunately at this point, the soft mud began to run in and block the hole and no efforts of the contractor were successful in clearing it, or in going deeper. It was essential that this should be done to give free flow to the water and to ascertain whether it would not overflow at the surface when the obstructions referred to were removed. The work requisite to effect this has proved both difficult and tedious, but is now, the 31st December, 1890, progressing favourably and it is hoped will terminate satisfactorily early in the ensuing year.

The total expenditure to date on account of it has been \$8,648.62. This has been derived and paid to the Deloraine Well Finance Committee, who had charge of the boring, as follows:—

Raised by municipal loan, grant from the Local Government and by subscription.. .	\$4,482 78
From Geological Survey appropriation, 1889-90	500 00
From special appropriation of \$2,000 voted by Parliament in 1890	1,997 54
From special appropriation of \$10,000 voted by Parliament in 1891	1,668 30
	<hr/>
	\$8,648 62

The well is still incomplete and it is impossible to state what further amount will be required to complete it, but it is hoped the cost in 1891 will not exceed an additional sum of \$2,000.

There seems little or no hope of finding any deep seated sources of fresh water in the Red River valley, east of the Pembina escarpment, or the first prairie-step. In places, however, a limited supply of fairly good water is obtained from shallow wells sunk in the superficial deposits of sand, clay and gravel with which the region is overspread. These deposits are very irregular in character and vary greatly in thickness, ranging from 0 feet to nearly 300. At the Lowe Farm, range 1, township 4, section 31, they were penetrated to a depth of 170 feet, leaving off in sand, with a supply of salt water which stands at 3 feet from the surface. Seven miles to south-west on range 2, town-

ship 4, section 17, a well was sunk 205 feet, the bottom being in similar sand with salt water which flows over slowly. Whether fresh water or salt water will be found in wells sunk in these deposits, within the area under consideration depends, in the first case, on the occurrence of permeable strata, that are not inclosed between others of an impermeable character, but communicate with the surface, and in the second case, on the character of the beds which immediately overlie the rocks from which the saline waters issue, with a strong upward pressure. If these beds are impermeable, then no salt water would be found in the wells above referred to that do not penetrate into the underlying salt water-bearing strata, as is the case at Rosenfeld, and at Morden, where, last year, a boring was made to a depth of 600 feet, and as had been predicted, salt water only was found. The upper strata of the superficial deposits in the Red River valley are largely impermeable dark clays sometimes reaching, as in the Lowe Farm wells, a thickness of 140 feet. These, of course, prevent any direct downward percolation and thus account both for the original swampy condition of large areas in the magnificent fertile belt of country which lies between the Red River and the base of the Pembina escarpment, and also for the general absence, or only very limited supply of fresh water in the wells of this district.

In the Turtle Mountain coal field, range 24, township 1, several pits and bore holes have been sunk and in all seams of lignite-coal of workable thickness have been struck. In one pit, now full of water, but said to be 50' 6" deep, strata are stated to have been passed through as follows :—

	Feet.	Inches.
Surface	3	0
Dark clay	4	0
Coal	5	6
Clay shale	10	0
Coal	3	6
Sandy brown shale	6	0
Soft whitey brown sandstone	2	0
Sandy clay	6	0
Coal	1	6
Friable whitey brown sandstone	12	0
Bored from bottom of shaft—sandstone	20	0
	<hr/>	<hr/>
	73	6

In another pit, 150 yards south of the one above described and about 15 feet higher, the coal was struck at 40 feet 4' 6" thick, then 12 feet sandy shale and thin bands of iron ore; coal 1' 6", then bored 35 feet through sandy shale; total 78' 6". This is the only pit from which any coal has been raised. An engine with winding gear and

shaft house have been erected here and a few tons of coal raised. This section is probably the most reliable, and omitting the upper 5' 6" seam of coal given in the first section which is probably a mistake—the two sections are much alike. The coal or lignite like that of the Souris at Roche Percée slacks on exposure and would not bear distant transport. The seams probably underlie the whole of the Turtle Mountain except where deep ravines have been cut out and have been filled in again with the superficial drift deposits. They will probably be found in places in township 1 from range 19 to 24. They could be mined at small cost, and for use among the settlers in the treeless country to the north and north-west between the Souris River and the Mountain would prove a cheaper and more economical fuel than wood.

I examined this district in 1883, and in the summary report for that year, page 2, it was stated "the evidence obtained clearly shows that there is every likelihood of workable seams being found here, as on the south flank of the mountains, at the head of Willow Creek in Dakota a seam has already been found showing from 3 to 5 feet of lignite of fair average quality." The seams now opened are doubtless the extension of those above referred to on Willow Creek, and as soon as railways are constructed to the mines, the lignite could be very advantageously distributed over a wide extent of country in which wood is even now scarce and costly and yearly becoming more so.

Leaving Manitoba on the 3rd of July, the first week in August was spent examining the sections between Banff, Field and Ottertail. Several promising deposits of silver-lead ore and copper ore were opened in this district in 1885-87. Some of them have changed hands since, more than once, at high figures, but the attempts to work them have been intermittent and insignificant. The Monarch mine, three miles and a half east of Field Station, is the only one on which any work was being done. At the time of my visit it was temporarily suspended, and the door of the gallery and level which have been constructed around the perpendicular face of Tunnel Mountain at 800 feet above the rails of the Canadian Pacific railway, was locked, and I could not examine the mine. This portion of the mountains and the mines that have been opened in them are well described in the Annual Report of the Geological Survey, Vol. II., Part D, by Mr. McConnell, 1886, and in Vol. III., Part R, by Dr. Dawson, 1888, and my present cursory examination has only enabled me to verify and to appreciate the accuracy of the reports referred to. That so little actual development has been achieved on these promising deposits on the Bow and Kicking Horse rivers since their discovery in 1886 is certainly to be regretted. It may in a great measure be attributed to the high prices at which the claims are held, the low grade of the ore and the cost of transport

to the smelter. The latter difficulty will, however, now be obviated by the construction this year of a smelter at Golden, already nearly completed.

A fine smelting plant has also been erected on the bank of the Columbia at Revelstoke. It was completed in the spring of 1890, but has not yet been put in operation. Last spring and summer, however, there was no immediate prospect of a sufficient supply of ore being available to keep the smelter running, nor was there likely to be till the Sproat-Nelson railway was completed. This, it is expected, will be accomplished this spring, and a great stimulus will then be given to the development and *bona fide* working not only of the West Kootanie mines, Nelson, Toad Mountain, Hendryx, Hot Springs and others, but also to the many promising but more distant deposits already discovered in the Selkirk and Rocky Mountain ranges between Golden, on the Columbia, and Castle Mountain, on the Upper Bow River. Seven days, from the 9th of August to the 16th, were occupied in a trip to Victoria, including two days with Dr. G. M. Dawson at Kamloops.

At Victoria very satisfactory arrangements were made by which to secure statistical and other information respecting the progress of mining development in the several remote and scattered mining districts in British Columbia. To effect this object, the Honourable John Robson, Provincial Secretary, very kindly issued the following circular letter to each of the District Commissioners of Mines:—

“ VICTORIA, 18th October, 1891.

“ SIR,—The Director of the Geological Survey Department, Ottawa, being desirous of obtaining full and prompt information appertaining to the mining and quarrying industries of the province, has suggested the appointment of ‘local correspondents’ as a medium by which his purpose can be accomplished.

“ In response to the desire expressed by Mr. Selwyn, I have to request that you will act in the capacity of local correspondent in your respective district, your functions as such, to consist in collecting general information on matters relating to new discoveries, new operations undertaken, and the progress of industries already established, and embodying the results of your inquiries in a letter at the end of each month. And also to supply information asked for in the accompanying directory book, which has been forwarded by Mr. Elfric Drew Ingall, the Mining Engineer in charge of the Division of Mineral Statistics and Mines.

“ It is further requested that you will commence to exercise your functions on the lines indicated without delay, it being clearly understood that your monthly letter to Ottawa, will not interfere with your Annual Report to the Minister of Mines.

"All communications should be addressed to the Geological Survey Department, Division of Mineral Statistics and Mines, Ottawa, and need not be stamped, as all mail matter addressed to the Government Departments in Ottawa, is carried free by the post office.

"I am, Sir, your obedient servant,

(Signed) "JOHN ROBSON,

"*Provincial Secretary.*"

In response, already some valuable and interesting information has been received, and the Mining Bureau of the Department may now expect to be fairly well posted on mineral production and mining development in British Columbia.

Returning eastward to Illecillewaet on the 16th of August, the next day was occupied in a visit to the Lanark and Maple Leaf mines situated 3,000 feet above the railway. Except driving a prospecting tunnel, then in progress, to cut the leads at a lower level, not much work has been done and no important developments appear to have been made since the date of my visit in 1886. On the 18th I visited the newly opened Gold Hill camp. A good pack trail to this camp has been made by the Provincial Government; it starts from the right bank of the Illecillewaet at about five miles above the village and ascends rapidly for three miles and a half in a northerly direction to about 2,800 or 3,000 feet above Illecillewaet. The country is quite open and well grassed with scattered groves of spruce and fir in sheltered places. The whole ridge was marked off in claims, and a number of small openings had been made, nearly all on bands of a rusty red weathering calcareo-magnesian rock associated with dark calcareous and brown shades or schists, very similar to those seen in the section on the railway in the vicinity of Illecillewaet; irregular and mostly thin bands of galena are seen in all the openings. What those veins may turn out when further developed it is impossible to predict. As regards most of them, however, my impression of their probable value was not favourable. The ridge on which they are situated is a triangular block of country about twelve miles long which lies between the Illecillewaet River and its north branch and in which also the Lanark Maple Leaf and other mines are situated. The dip is fairly regular to E.N.E. $<35^{\circ}-85^{\circ}$, the veins run with the strike; but in dip appear often to pass from one bed plane to another, and are probably more nearly coincident with the planes of schistosity or cleavage than with those of bedding. In my Summary Report for 1887 in reference to the Illecillewaet black slates it was suggested they might be of Silurian (Ordovician) age. It is now almost certain they are near the base of the Cambrian and probably represent nearly the horizon of the silver-bearing Animikie rocks of Lake Superior; beneath them there is a

great thickness of flaggy, brown and grey quartzites and gneissic schists becoming more granitoid and crystalline to the westward. Much more detailed examinations, however, are required in eastern and south-eastern British Columbia before the precise relations of the different groups of strata can be definitely determined.

At Albert Cañon, near the base of the Illecillewaet dark slaty series, is a bed of excellent crystalline grey limestone apparently about 25 to 40 feet thick, it crosses the rails at the look-out platform with a dip of about 30° to N.N.E. and is very favourably situated for the establishment of a lime-burning industry. The occurrence of limestone in this region was not known when I mentioned it to gentlemen in Revelstoke. All the lime hitherto used there, and for considerable distances both east and west, having been brought from the Pacific coast.

From the 21st to the 29th of August was devoted to a trip from Revelstoke to the Kootanie mining camps, Sproat, Nelson, Hendryx and Hot Springs. For description and map of the district, Part B. of the Annual Report, Vol. IV., '89-90, can be referred to and my brief visit does not enable me to add anything of importance to Dr. Dawson's report above referred to. I may, however, express an opinion from what I saw that the mines in this district will prove much richer and more permanent than those of the Illecillewaet district. My reason for so thinking being based on the fact that experience has shown that the association of granitoid and other crystalline rocks, porphyries, felsites, diabases, &c., generally exerts a favourable influence on the productiveness of metalliferous deposits, and that, while such rocks are abundant in the Kootanie district, they appear to be entirely wanting or of very exceptional occurrence, in the ranges at the sources of the Bow and the Kicking Horse or Wapta rivers. As, however, they often occur in narrow bands or dykes they easily escape the notice of prospectors; they should, therefore, be carefully looked for, as in the richest mining districts to the south, they almost invariably accompany and are indicative of the most productive ore bodies.

On the 29th of August, a short time was spent at Canmore to look at the coal mines newly opened there on the seams on the right bank of the river described, pages B-132 and 133, Annual Report, Geological Survey, Vol. I., 1885. The three-feet seam is now being worked by a slope which starts on a terrace about 200 feet above the river, where a small outcrop of the measures is exposed dipping 50° to 60° to westward. In a level being driven into the hill to cross-cut the seams, about 100 feet below the slope, the dark shales associated with the coal had been struck at about 30 feet in dipping 30° to north-east, so that there must be either a fault or a steep anticlinal fold along the face of the hill. The coal is much crushed and sicken-

sided. It is apparently a semi-anthracite, like that from Cascade River—see analysis, Part M., Annual Report, Geological Survey, Vol. I., 1885. There can be little doubt that the Canmore seams are the extension of those of Cascade River and Anthracite on the opposite side of the Bow River valley. The mine is already connected by a branch railway with the station at Canmore; an incline tramway and shipping stages have been constructed at the mine and there is now every convenience for handling a large output.

On the 30th of August I left Calgary for Macleod, with the intention of visiting the Crow's Nest Pass petroleum discoveries, but being unfortunately prevented from doing so, returned *via* Lethbridge and Dunmore to Manitoba and after again visiting the Deloraine boring reached Ottawa on the 19th of September.

The greater part of October and up to the 5th of November, was occupied with matters relating to the formal invitation from the Canadian Government to the members of the Iron and Steel Institute of Great Britain and the Association of German Iron Masters, then assembled in New York, to visit Canada. Nearly 100 members accepted the invitation and on the 29th of October, they were received at Niagara by a committee on behalf of the Canadian Government and were accompanied thence *via* Hamilton, Toronto and Sudbury to Ottawa and Montreal.

Dr. G. M. Dawson left Ottawa for field work in the southern part of the province of British Columbia on the 5th of June, returning on the 28th of October. He was assisted as before by Mr. J. McEvoy, and for a portion of the season by Mr. A. T. Kirkpatrick. Dr. Dawson furnishes the following summary of the work carried out:—

"At the conclusion of field work in 1889, there still remained a part of the area comprised in the 'Kamloops sheet' of the geological map which had not been examined, and for which both geological and topographical information was required. This portion of the area of the proposed map included a belt of mountainous country to the west of the Fraser River, together with several other smaller separated areas, and the work necessary for the completion of the sheet naturally first received attention. As in former years, the topographical work was carried out chiefly by Mr. McEvoy, while the concurrent geological examinations occupied the greater part of my own time. The size and boundaries of the Kamloops sheet having been noted in the last Summary Report (p. 7), need not here be further alluded to.

"After finishing the work above referred to, necessary for the completion of this sheet to the degree of accuracy and detail which appears to be at present practically requisite, some time was spent on the area

of the adjoining sheet to the east, which it is proposed to designate the 'Shuswap sheet,' and before returning, in the autumn, a preliminary examination was also made of the geological section found in the Selkirk Mountains in the vicinity of the line of the Canadian Pacific Railway. This examination was undertaken principally with the object of connecting our knowledge of the rocks of the Interior Plateau (in the area of which the Kamloops sheet and most of the Shuswap sheet are included) with that of the formations of the Rocky Mountains proper, where palaeontological evidences of age are more abundant and in which one section has been carefully examined and described by Mr. McConnell. Part D, Annual Report, Geological Survey, Vol. II., 1886.

"The working up of the topographical and geological data obtained for the Kamloops sheet, the plotting of sections and study of specimens brought back, are now in progress in the office, and will fully occupy the entire winter. No detailed report can be prepared till this work shall have been completed, but some points connected with last summer's field operations may be mentioned.

"It was found impossible to examine in much detail the Alpine region to the west of the Fraser, constituting the eastern border of the great Cascade or Coast Range of British Columbia, without the expenditure of a large amount of time; and as the rocks were found to consist for the most part of gray granites, monotonous in character and apparently of no economic importance, it was considered sufficient to gain a general knowledge of this region. In 1889, several high summits opposite the eastern front of this range and to the east of the Fraser valley had been occupied as transit stations and observation points, but in consequence of stormy weather and the smoky state of the atmosphere, even the main features of the range had been very imperfectly seen or delineated. To fix the main peaks in the range, two additional summits, each about 6,000 feet in height, were first occupied one being to the north and the other to the south of Lytton, and both on the east side of the Fraser. The Fraser River was then crossed at Lytton and three summits in the eastern part of the Coast Range itself were successively occupied as transit stations and look-out points, the heights of these being 8,130, 8,960 and 7,430 feet respectively. Some excursions were also made in the range, and the entire belt of foot-hills between its base and the Fraser was examined. In the course of this work several zones of schistose rocks which traverse the granites were outlined and the border of the Cretaceous rocks was definitely located for the whole distance. These latter rocks occur in the form of a long narrow trough (very imperfectly shown on the general map of 1877), which is followed by the Fraser River. They are most-

ly of Earlier Cretaceous age, being equivalent to the Queen-Charlotte Islands and Kootanie series,* and to the Shasta group of California. A small collection of fossil plants obtained at one place appears, however, to show that strata as new as those of the Dakota series are also included. The occurrence of these plant remains, together with the presence of carbonaceous shales in several places, affords some reason to hope that coal may exist in some part of the area occupied by the Cretaceous rocks in this portion of the province, though none has so far been discovered.

"A good general idea of the character of that part of the Coast Range which lies between the Fraser and Harrison and Lillooet Lakes, to the west of the Kamloops sheet, was gained from the high peaks ascended. The culminating mountains are rough and wide in outline, and though none of them are specially dominant in altitude, several attain or somewhat exceed a height of 10,000 feet. They include very extensive snow-fields and numerous small glaciers, and will afford an interesting and not extremely difficult field for alpine climbing and exploration.

"Later in the summer a log-survey of Kuk-waus or Bonaparte Lake was made. This lake was seen by Mr. McEvoy in 1889, but has not appeared on any published map. It lies forty miles north of Kamloops and proved to be ten miles in length. The Bonaparte River issues as a small stream from its west end, and the rocks along its shores are entirely granitic, though Tertiary basalt caps many of the hills at no great distance from it. On the south from this lake the eroded edge of the basaltic rocks to the west of the North Thompson was traced in detail.

"While the volcanic rocks of the Tertiary, just alluded to, and which cover large parts of the Kamloops sheet, often rest directly on granites or other ancient rocks, they also in certain districts form the upper member of a Tertiary series of some thickness, of which the lower part consists of ordinary stratified rocks locally characterized by the occurrence of coal or lignite. One of the more important results of the work now done on this sheet, is the definition of the areas in which such fuels exist or in which they may be sought for with reasonable prospects of success.

"The best known occurrences of coal or lignite in the area of the Kamloops sheet or in its immediate vicinity are those on the Nicola and North Thompson rivers and Hat Creek with that near the town of Kamloops. These have already been described, and no new facts of importance concerning them can be obtained till further exploratory work has been carried out by boring or otherwise. A reported coal

* Am. Journ. Sci., Vol. XXXVIII, p. 120.

discovery on the Bonaparte, within a few miles of Ashcroft, was visited, but proved to be unimportant, because of the thinness of the seam, and the very small area of the Tertiary outlier in which it is contained. It is, however, of interest as showing the occurrence of coal in the base of the Tertiary rocks of this vicinity, and points to the desirability of testing the adjacent larger Tertiary areas by boring, for which a site might be chosen to the north of the road between Câche Creek and Eight-Mile Creek. The further investigation of the coal-bearing basin near the town of Kamloops, should be made by boring near the line of railway and west of the town, or on the opposite side of the lake near the point at which the main irrigation ditch leaves the Tranquille River. A boring near the mouth of the Nicola would also be desirable, in order to test the possible extension of coal westward from the known outcrops near the mouth of the Coldwater, to the Thompson; while a boring in the western edge of the Tertiary near the mouth of the Nicomen River, below Spence's Bridge, would not be without importance in the same connection.

"The metalliferous deposits in the vicinity of Stump Lake, referred to in the Summary Report for 1888 (p. 8) and in the Mineral Wealth of British Columbia (p. 69 r.), notwithstanding the favourable conditions for their development and the high assay value of some of the ores, have not yet assumed a position of permanent importance. The Nicola Mining and Milling Company have now sunk in the 'Joshua' shaft to a depth of about 400 feet, and have done considerable drifting, for the purpose of exploration, but with this exception 'assessment work' only has been carried out on the various claims taken up in this vicinity. The general parallelism and the evident connection of the veins of this locality with the outline of the great granitic area to the west rendering it important that this should be done, the remaining part of the line of contact of this granite with the stratified rocks was traced in detail. The vicinity of this line of contact, like that of several other similar contact lines and numerous places not distinctly connected with granitic masses, is characterized by a great abundance of vein quartz. Many specimens of such veins have been collected for the purpose of assay, the results of which it is hoped will afford some definite information as to the habitus and mode of occurrence of the gold and silver ores.

"A point of some interest in connection with the stratigraphy of the Kamloops sheet, is the discovery of fossils representing the characteristic Alpine Trias fauna, which was made last summer in the hills north-east of Savona. The evidence heretofore obtained pointing to the existence of these rocks in this part of the Interior Plateau region had been rather imperfect.

"In the course of the preliminary work done on the Shuswap sheet, the Monashee Mine, situated on the watershed between Cherry Creek and Kettle River, in process of development by Mr. D. McIntyre, was visited. There are at this place several distinct veins of auriferous quartz in which specks of free gold are frequently visible. These veins, in which points of gold are often visible, traverse Monashee Mountain, composed of quartzite, diabase (?) and limestone strata, near to the margin of a wide granitic mass, which lies to the south. Several small tunnels and openings have been made on the veins, and a small mill has been erected with a view to commencing work on the ore in the spring. A number of small specimens selected from the ore at the mouth of the principal working drift at this place, have been proved on assay by Mr. Hoffmann, to contain, gold 0·583 oz., silver 2·683 oz. to the ton.

"The preliminary examination of the section across the Selkirk Range, near the line of railway, which has already been alluded to, shows that the western part of this portion of the range consists of gneissic rocks and other crystalline schists of the Shuswap series,* probably Archæan. Above these, and further to the east, is a mass of rocks composed principally of dark argillites, passing into micaceous schists, with a thickness of about 15,000 feet. These evidently represent the Nisconlith series of the Interior Plateau and correspond in a general way to the Bow River series of the Rocky Mountains. The argentiferous lead ores of the vicinity of Illecillewaet occur in these rocks, which are believed to be of Lower Cambrian age.

"Overlying the Nisconlith series and forming a great synclinal in the axial part of the range, is a series chiefly composed of schists and quartzites, with apparently a total thickness of about 25,000 feet. This is believed to correspond to the Adams Lake schists on the west, and to the Castle Mountain group, with a portion of the upper part of the Bow River group in the Rocky Mountains, and very probably includes beds ranging in age from the Lower Cambrian to the Cambro-Silurian. Still newer strata appear to be represented on the eastern flanks of the Selkirk Range, probably representing the Graptolitic shales and Haly-sites beds of the Rocky Mountain section. The partial correlation of the beds of the Rocky Mountains proper with those of the Interior Plateau which this section enables us to reach, is a point of some importance, but the Selkirk and Columbian ranges require to be studied in greater detail before the different parts of the Cordillera in British Columbia can be satisfactorily compared."

* See Report on a Portion of West Kootanie District, 1889, p. 31B.

Mr. McConnell left Ottawa on the 2nd of May to continue the exploration of the Athabasca petroleum region, commenced in 1889. (See pp. 10 to 12 of the Summary Report for 1889.) On this season's work he reports as follows :—

"On the 19th of May I left Athabasca Landing, ninety miles north of Edmonton, with one canoe and two men. It was considered advisable to utilize the early part of the season in examining as many of the tributary streams as possible, as after July most of these become unnavigable, therefore little work was attempted in descending the river. Records of a number of interesting sections were, however, obtained at various points.

"We reached Fort Chipewyan, on Lake Athabasca, on the 3rd of June, and on the 15th left for the Birch Mountains. We ascended the Quatre Fourche Fork of Peace River, crossed Lake Mammawee and then by utilizing a number of old river channels and making a few short portages reached Lake Claire. This lake, together with Lake Mammawee and a large number of smaller water basins, occupies the delta-plain which stretches from the west end of Lake Athabasca far up the Athabasca and the Peace. They represent portions of Lake Athabasca separated from the main basin by accumulations of stream detritus. They are everywhere very shallow, and at ordinary stages of the water seldom exceed nine feet in depth even in their deepest parts. In seasons of exceptionally high water the low marshy plain separating them from the main lake and from each other is flooded, and they become united into one broad sheet of water. Lake Claire is the largest of the group, and has a width of from ten to fifteen miles and a length of from twenty-five to thirty miles. The northern part has not yet been surveyed. The shore line is irregular and is broken by a succession of long points and deep bays. At Pointe de Roche on the west side of the lake a greyish, granular limestone is exposed which holds *Atrypa reticularis* and is probably a continuation of the same Devonian limestone which is found along the Athabasca. This was the only exposure of the older rocks noticed on the part of the lake examined.

"The two principal streams flowing into Lake Claire are Cut-bank River and Birch River, both of which head in the Birch Mountains, the former draining the eastern and the latter the western slopes of the range. I ascended both these streams for some distance. Cut-bank River was followed for about thirty miles by the course of the stream, but probably not more than fifteen miles in a straight line, and then leaving the main stream I followed a tributary which led through a deep valley directly into the Birch Mountain plateau. In the lower part of Cut-bank River Devonian limestones cross the valley at several

points and form small rapids, but in the upper part only recent sands and clays are seen.

"The Birch Mountains were examined for the first time during the present season's exploration. They consist of an elevated plateau, running in a north-and-south direction, or nearly parallel to the course of the Athabasca, from which they are separated by a flat, fifteen to twenty miles wide. The plateau is from fifteen to thirty miles wide. The surface is undulating and is broken by numerous lakes, most of which drain eastward into the Athabasca. Around the northern end the slopes are steep, and the highest points rise to an elevation of about 1,200 feet above Lake Claire, or about 2,000 feet above the sea. Further to the south the slopes become less abrupt and the relative elevation above the bordering plains is also somewhat less.

"Genetically the Birch Mountains are simply a denudation plateau and consist of almost horizontal Cretaceous strata. A band of yellowish and greyish sands and soft sandstones outcrops at various points around the northern end of the hills. These beds are destitute of fossils, but were referred on stratigraphical grounds to the horizon of the Niobrara. They contain small coaly seams, and some of the beds are blackened with bituminous matter, and resemble in this respect the Dakota tar-bearing sands found along the Athabasca. The sands exposed here have a thickness of 200 feet, but the base was not seen. They are overlaid by 150 feet of dark Pierre shales. The beds underlying the Niobrara and forming the base of the mountains were concealed at the point examined.

"Birch River and one of its tributaries, Swift-current Creek, were explored for some distance, but offered little geological information, as they have not cut through the alluvial mantle which covers in this region the older rocks.

"After returning from Birch River I coasted along the southern shore of Lake Athabasca as far as Point William, where I was stopped by the ice (June 25). This shore as a rule is low, and is bordered for long distances by low bluffs of stratified sands and clays. At Pointe de Roche, and at a couple of other places, the basement rocks come to the surface and were found to consist of a granular siliceous sandstone which, from its general character and position may be referred to the Cambrian, and probably belongs to one of the lower divisions of this system. For reference it may be called the 'Athabasca sandstone.' No fossils were found in it, nor was its contact with the overlying or underlying rocks observed. This sandstone is usually coarsely granular in texture, but occasionally passes into a fine-grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed

by the textural differences. It is cut by two systems of jointage planes, and in weathering breaks up into huge blocks, some of which contain several hundred cubic yards of material. Numerous fragments, some of large size, of a mottled rather fine-grained sandstone, somewhat similar in appearance to that occurring at Sault Ste. Marie were noticed strewn along the beach, but were not found *in situ*. The Athabasca sandstone apparently extends all along the southern shore of Lake Athabasca, as specimens brought by Mr. Cochrane in 1882, from the east end of the lake cannot be distinguished in appearance from those collected at Pointe de Roche and neighbouring localities. Its extension southwards cannot be as yet approximately determined. On the north, its junction with the Archæan is concealed beneath the waters of Lake Athabasca.

"After leaving the lake, I ascended the Athabasca River, and on the way up examined portions of Muskeg River, Lower Steep-bank River, of Dr. Bell's map, Jackfish River, Steep-bank River, Red River and the North Pembina. A second trip was also made into the Birch Mountains, with Moose Lake situated on the summit of the range for its objective point. At the lake I was fortunate enough to obtain a couple of birch bark canoes, and on the return journey, Moose River, the outlet of Moose Lake, was followed in its headlong career down the mountain side and across the bordering plain to near its junction with the Athabasca. This river has a fall of 1,200 feet in about thirty miles, and in its course cuts through all the Cretaceous strata from the Pierre shales down to the Dakota sands.

"The valley of the Athabasca for a hundred miles above Lake Athabasca shows only alluvial sands, and the boulder-clays associated with stratified sands and gravels. Beds of rolled tar-sand pebbles occur in the latter in a number of places. A coarse gravel bed which immediately underlies the surface, and overlies the boulder clay was found to be completely saturated with soft tar. Ten miles below Calumet River the Devonian limestone rises to the surface of the valley from beneath the glacial beds and almost immediately afterwards is overlaid by the tar-bearing sands of the Cretaceous. From this point the Devonian limestones undulating at low angles, and accompanied by the tar-sands, are exposed at frequent intervals as far as Crooked Rapid, a distance of about eighty miles. At Crooked Rapid they become affected by a slight south-westerly dip and sink below the surface of the valley, and eight miles farther on, at Boiler Rapid, the tar-sands disappear, and are replaced by higher divisions of the Cretaceous.

"The tar-sands mentioned above belong to the Dakota formation and constitute in this region the basal member of the Cretaceous system. They rest unconformably on the Devonian limestones. Litho-

logically they may be described as soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the underlying limestones. The sands are siliceous and usually rather fine-grained, but also grade occasionally into a coherent grit. The eastern boundary of the tar-sands was not precisely defined, but their outcrop was estimated to have a minimum distribution of fully 1,000 square miles. In thickness they vary from 150 to 225 feet. The tar is unequally distributed through the sands, in some places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell gave by weight :—

Bitumen	12·42
Water (mechanically mixed).....	5·85
Siliceous sands	81·73

A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117·5 lbs. This figure multiplied by the percentage of bitumen, 12·42, gives 14·59 lbs. as the amount of bitumen present in a cubic foot, or $\frac{14\cdot59}{6\cdot5} = 22\cdot9$ per cent in bulk. At the minimum thickness of 150 feet, and assuming the thickness as given above at 1,000 square miles, the bituminous sand rock in sight amounts to 28·40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although this is probably rather high, 22·9 per cent in bulk or 6·50 cubic miles is bitumen. This calculation can, of course, only be regarded as an approximation, but will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region. The amount of petroleum which must have issued from the underlying limestones required to produce 6·50 cubic miles of bitumen cannot be estimated, as the conditions of oxidation and the original composition of the oil are unknown. It must, however, have been much greater than the amount of bitumen.

"A few miles west of the Athabasca the sand rock, still saturated with tar, passes below the higher divisions of the Cretaceous, and its extension in this direction can only be ascertained by boring. It was not recognized on Peace River nor on the lower part of Red River, and must disappear somewhere in the intervening region.

"In ascending the Athabasca the tar-sands, after an exposure of over twenty miles, pass below the surface at Boiler Rapid and are not seen again. Above this the upper divisions of the Cretaceous, influenced by a light south-westerly dip, and also by the grade of the stream descend gradually in the banks of the valley and disappear in succession. The Cretaceous section is as follows in descending order :—

	Feet.
Pierre shales	700
Niobrara sand and sandstone	35
Niobrara shales	90
Niobrara sand and sandstone	300
Benton shales	275
Dakota tar-sands	175
	<hr/>
	1,575

Devonian limestone

"The commercial value of the tar-sands themselves, as exposed at the surface, is at present uncertain, but the abundance of the material and the high percentage of bitumen which it contains makes it probable that it might, in the future, be probably utilized for various purposes. It proves a flow of petroleum to the surface unequalled elsewhere in the world, but its more volatile constituents have long since disappeared, and the rocks from which it issued are probably exhausted. In their extension under cover, however, the case is different, and it is here that oils of economic value must be sought. Above Boiler Rapid the tar-sands are overlaid by a cover of shales sufficient to prevent the oil from rising to the surface, and as we ascend the river this cover gradually thickens. The geological attitude of the cover is not the most favourable, as the beds dip away from the outcrop at the rate of about six feet to the mile, and it is possible that part or even the whole of the oil may have flowed northwards and eastwards through the Dakota sands and escaped where these come to the surface. It is unlikely, however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the sands themselves may serve to inclose reservoirs or pools of large capacity. It is also possible that the sands at their outcrop may, by the deposition of tarry substances, be plugged tightly enough to prevent further egress.

"Favourable indications of the presence of oil are afforded by the existence of several natural gas springs in the valley of the Athabasca above Boiler Rapid. One of these occurs at the mouth of Little Buffalo River and is twenty miles distant in a straight line from the outcrop of the tar-sands. The gas here forces its way from the sands up through a covering of 250 feet of Benton shales and issues from the surface in numerous small jets distributed over an area fifty feet or more in diameter. Some of the jets when lighted burn steadily until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed thirteen miles below the mouth of Pelican River, or forty miles in a straight line from the outcrop of the tar-sands at Boiler Rapid. The volume

of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sand. Escaping jets of gas were also noticed at several points further up the river, but these were mostly small and may possibly be due to decaying vegetable matter.

"The question of the continuity of the tar-sands, and their petrolierous character under cover, can only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. The indications seem amply sufficient to warrant the small expenditure involved, and the advantages which would accrue from a successful issue of the search to this portion of the North-west are almost incalculable. The southern limit of the field cannot, with our present knowledge or without boring, be defined; it may possibly extend to the Saskatchewan or beyond, as, even as far as Manitoba, the rocks are more or less petrolierous.

"Two bore holes, one at the mouth of Lac la Biche River, and the other at the mouth of the Pelican, would add largely to our knowledge of the underground geology of this region, and would either settle positively the question as to the presence or absence of petroleum in paying quantities, or at least afford valuable data for future action. At the mouth of the Pelican River, a bore hole, in order to reach the tar-sands, would require to be sunk 700 feet, and at the mouth of Lac la Biche River about 1,200 feet. The former locality is 50 miles distant in a straight line from the outcrop of tar-sand at Boiler Rapid. The latter is 106 miles distant from the same point, and is only 110 miles from Edmonton."

Mr. J. B. Tyrrell spent the winter examining the large collection of rocks and fossils gathered in North-western Manitoba during the previous summer, and preparing for the publication of a report on that district.

A specimen of phosphatic shale collected by him from the Niobrara formation on Wilson River, on the Lake Dauphin Plain in Manitoba, was given for analysis to Mr. Hoffmann, who reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. A very small outcropping of this shale, which is largely composed of fragments of fish remains, was seen in the bank of the river, but if the bed proves to be an extensive one, it will furnish a very valuable source of supply of phosphate of lime for the benefit of Manitoba and the country further west, being very similar in character to the coprolite beds of England and France.

During the past summer Mr. J. B. Tyrrell, assisted by Mr. D. B. Dowling, continued the geological survey of the northern portion of the province of Manitoba. Mr. Tyrrell reports as follows:—

"Leaving Ottawa on the 2nd of June, I proceeded to Winnipeg, where preliminary arrangements were made for obtaining money and supplies for the year. From Winnipeg I instructed Mr. Dowling to proceed to Minnedosa *via* the Manitoba and North-western railway, and there obtain horses and men and drive north on the Lake Dauphin trail to the crossing of Ochre River, in order to complete the geology and topography of the south-eastern corner of the map of North-western Manitoba, shortly to be published. On his return from Minnedosa he was instructed to start from Selkirk with a boat and two men, and survey with compass and micrometer or floating boat log the many islands in the northern and western portions of the lake, to note their character, mark any rock exposures, and collect fossils whenever they were to be found.

"This partition of the party was considered advisable as a larger amount of work could thus be performed during the present season, and a reliable map obtained with which to carry on the geological exploration of Lake Winnipeg during the coming summer.

"At the same time I proceeded by rail to Russell, where I had the good fortune to find Mr. Donald Sinclair, who has formed one of my party since 1887. From Russell we drove northward to Fort Pelly at the elbow of the Assiniboine River, from which point I purposed descending the river to Portage la Prairie.

"On the 15th of June, accompanied by one man, I started down this stream in a little canvas canoe. The river is very narrow and tortuous, winding too and fro in a shallow secondary valley in the bottom of a basin-like trough west of the northern portion of the Duck Mountain. Proceeding a short distance, low banks of dark grey clay belonging to the Millwood subdivision of the Pierre shales begin to put in an appearance in little scarps on the outer banks of the river. Near the first of these lies a large boulder consisting of a spherical nodule of Dakota sandstone quite similar to the large nodules which form a conspicuous feature on Kettle Hill at the south end of Swan Lake. If this nodule has been carried by the Laurentide glacier from Kettle Hill, its occurrence here would determine the direction of flow of the ice for this locality at one time in the glacial period as S. 55° W. or directly up the wide valley of the Swan River, rising, in the seventy-three miles travelled, more than four hundred feet. In the same vicinity many rounded or lenticular nodules of calcareous ironstone are to be seen sliding down the face of the bank.

"Proceeding down the river the channel was found to be very tortuous, winding through the alluvial bottom land. The valley gradually becomes more sharply defined till, just below the mouth of Little Boggy Creek, its banks rise abruptly on either hand to a height

of more than two hundred feet. At some of its bends the river impinges on the outer bank of the valley, and either cuts a cliff of dark grey Millwood shale, holding occasional nodules of ironstone, or grey-jointed till from which striated boulders of gneiss and limestone are falling. At the base of these cliffs the accumulation of boulders gives rise to miniature rapids, which break the usual quiet flow of the stream. It is a circumstance very worthy of remark that the river does not appear to carry boulders any considerable distance down its channel, as they are found for only but a very little way below the cliff from which they are falling.

"The sides of the valley are everywhere seen to be composed of Millwood shale, till, or alluvial deposits all the way down to the mouth of Bird Tail Creek. In this distance the banks are in places beautifully terraced, the terraces rising as regular grass-covered steps, one above another. They are well shown at the village of Shellmouth, which has a most charming situation on the open sandy terraces that rise from the east bank of the Assiniboine River till they abut against the side of the main valley.

"Near Fort Ellice the banks of the river in some places are composed of boulders beaten down to an even slope by the ice, showing excellent examples of boulder pavements formed by river ice. Their surfaces were, however, neither worn nor scratched like the glaciated pebbles seen in the till.

"Shortly below the mouth of Bird Tail Creek pebbles of Pierre shale, Odanah series, begin to appear in the till.

"A few miles above the mouth of Arrow River, the top of the bank of the valley is found for the first time to be composed of the light green grey hard fissile shales of the Odanah series. These shales form a prominent feature as far east as Oak Lake, often giving rise to bare rounded buttes on the sides of the valley, reminding one strongly of the bad lands of many of the arid regions of the west.

"At the Sioux Indian Reserve the valley becomes wider and more open, and at a point north of Alexander a gravel plain indicates the position of the ancient mouth of the Little Saskatchewan.

"From this gravel plain to near the mouth of Cypress Creek no Cretaceous rock is seen in place, but the banks are composed of till or alluvial deposits, while the channel is occasionally blocked by an accumulation of boulders.

"At the mouth of Cypress Creek a dark grey shale outcrops in low exposures near the edge of the water, possibly representing the bottom beds of the Millwood series of the Pierre. A short distance further down the river fragmental limestone and marl, typical of the Niobrara

formation, gradually rise above the water to a height of 15 feet. This rock is directly overlain by till and at the lowest exposure in S. 23, T. 9, R. 10 W., where the marlith rises highest above the water, its surface is beautifully and evenly striated, the striae bearing S. 38° E. As the valley is here 120 feet deep it is possible that these striae do not give the exact direction of flow of the ancient glacier, but they would indicate that it had an easterly rather than a westerly trend. From the lowest outcrops of the Niobrara marlith to Portage la Prairie, no cliffs of rock are seen on the river, but its bed appears to be composed of the dark grey shale of the Benton formation which usually weathers with a very lightly sloping surface.

"We arrived at Portage la Prairie on the 15th of July, having spent precisely a month on our journey down the river from Fort Pelly.

"I proceeded at once to Winnipeg and found that Mr. Dowling had completed the survey of the small area on the face of the Riding Mountain, south of Lake Dauphin, and had gone at once to Selkirk.

"On the 17th of July I went from Winnipeg to Morden, and there, through the kindness of Mr. Dunsford and other gentlemen, obtained the log of the well that had been drilled by the village for the purpose of obtaining a large and permanent supply of fresh water. A few specimens had been kept typical of the various strata passed through by the drill, and these were kindly handed over to me and are at present under investigation. A hurried examination made on the spot showed that the well had been begun in the Pierre shales, had passed through the Niobrara, Benton, and Dakota formations, and had penetrated a considerable distance into Palæozoic shales and limestones. A large flow of salt water had been obtained in the Dakota sandstone. The record of the Rosenfeld well shows that fresh water is not to be hoped for from the Palæozoic strata, so that I was obliged to advise the people of Morden that there was no probability of obtaining fresh water by sinking the well to a greater depth. The work of boring was therefore discontinued, having been carried to a depth of 600 feet.

"It is quite probable, however, that the village can readily obtain a large supply of water from the gravel bed that stretches eastward from the mouth of Horse Creek.

"The next day I returned to Winnipeg and thence went on to West Selkirk where I found that the boat built under my instructions by Wm. Watts & Co., of Collingwood, for coasting work, had already arrived. I was also met by Mr. L. M. Lambe, the artist of the Palæontological branch of the Geological Survey, who had come from Ottawa to join my party to assist in collecting fossils from the Cambro-Silurian rocks on the shores and islands of Lake Winnipeg.

"James Collins, who had already spent eight years on Lake Winnipeg, was hired as sailor, and supplies and any goods necessary to complete the outfit were obtained from Messrs. Robinson & Co.

"On the evening of the 22nd of July, we embarked on the steam barge *Red River*, bound for the Grand Rapids at the mouth of the Saskatchewan. On the way we left Mr. Lambe at Dog's Head to join Mr. Dowling.

"Shortly before noon on the 25th of July we arrived at the fish-packing station at Grand Rapids, and from there we took our goods and supplies in the small sailboat up to the Hudson Bay Company's warehouse at the lower end of the tramway, a mile further up the river. That evening, Abraham Scott, an Indian, who was thoroughly acquainted with the river as far up as Cedar Lake, was added to the party.

"The next morning we loaded the boat, with all necessary supplies for two weeks, on a flat car; to this car a horse was hitched and we rode to the other end of the tramway at the landing above the Grand Rapids. At this place we launched the boat and ascended the Saskatchewan River with oars, poles or tow line to Cedar Lake. A survey was made with compass and floating boat log of the south shore of Cedar Lake, and the river examined up to the Hudson Bay Company's Post at Chemahawin. Here an Indian showed me a piece of amber, and stated that he had found it in the vicinity. The next day I had the pleasure of meeting Mr. King, of the Hudson Bay Company, who kindly accompanied me to the place where the amber was found, on the west shore of Cedar Lake, near the mouth of the Saskatchewan River.

"It occurs mixed with sand and many fragments of partly decayed wood, on a low beach behind a gradually shelving shore and along the face of a deep, wet spruce swamp. The pieces were for the most part smaller than a pea, but could be readily seen glittering among the sand and vegetable débris. Some pieces were found as large as a robin's egg, and Mr. King informed me that he had collected pieces very much larger. It has evidently been washed up on the shore by the waves, but its exact age has not yet been positively determined.

"The first place at which it was seen was in a small bay behind a limestone point projecting towards the north, but the most extensive deposit is more than a mile south of this point, where a rounded beach stretches across the margin of a low swamp. This beach is about a mile in length, and from eighty to one hundred and twenty feet in breadth. The amber is found most plentifully along its ridge, where it constitutes between five and ten per cent by volume of the sand and

vegetable débris, and holes dug to a depth of two feet show no diminution in its quantity. Towards the edge of the lake, however, the sand is freer, both from fragments of wood and amber.

"It is difficult to make an accurate estimate of the quantity of amber on this mile of beach, but it may confidently be said to be found throughout the distance in a band thirty feet wide, with a minimum depth of two feet. This band has thus a total bulk of 316,800 cubic feet. A number of specimens collected from various parts of it showed an average of a little over ten per cent of amber, which, in natural fragments, weighed forty-six pounds to the cubic foot. The amount of amber on this strip of beach would, therefore, be about 31,680 cubic feet, or 1,457,280 pounds. At a minimum value of twenty-five cents a pound, this would represent a total of \$364,320. This estimate refers merely to the material that is now washed up on the ridge of the beach, without considering the source from which it is originally derived.

"Returning down the river, the rocky islands at the western end of Cedar Lake, and the islands and the shore of the east end of the same lake were surveyed. Instead of again taking advantage of the tramway we ran our boat through the Grand Rapids, and for a few short moments enjoyed the exhilaration of being tossed about on the surging waters of the grandest part of one of the grandest rivers in the Canadian North-west. There is some error in the computation of the fall of this rapid made by Mr. John Fleming, when acting as Professor Hind's assistant. The fall is given by him at $43\frac{1}{2}$ feet, whereas the actual fall, from top to bottom of the rapid is in the vicinity of 100 feet.

"The rock outcropping on Cedar Lake was found to be the same as that on the north-east shore of Lake Winnipegosis. It was, however, here found to contain a much larger number of fossils, which clearly determine its age as about that of the Niagara formation of Iowa and Wisconsin. The rock through which the river has cut its gorge at the Grand Rapids also belongs to the same formation.

"On the tramway between the upper and lower ends of the rapids several well defined gravel ridges are crossed at altitudes from 100 to 120 feet above Lake Winnipeg. These probably represent the shore lines of Lake Agassiz when it stood at the Stonewall Stage described by Mr. Upham in Part E. Ann. Rep. Geol. Survey, Vol. IV., 1888-89.

"Leaving the mouth of the Saskatchewan we coasted northward down the shore of Lake Winnipeg to its extreme north-west angle in Limestone Bay. Wherever rock outcrops were observed they were found to be Cambro-Silurian limestones of about the age of the Trenton or Utica formations.

"Limestone Bay is cut off from the rest of the lake by a narrow spit of sand twelve miles in length projecting towards the south-west. From the base of this spit an even unbroken sand beach stretches eastward to near Mossy Point, while behind the beach is an almost vertical cliff, rising in some places to a height of forty feet, composed at the bottom of a stiff blue alluvial clay, and at the top of a mossy peat. Rounding Mossy Point we descended Nelson River through Playgreen Lake to Norway House, and on our return made a log survey through Little Playgreen Lake, by a channel not previously mapped, into Playgreen Lake and thence by Warren's Landing to Lake Winnipeg. Nelson River at the discharge of this lake flows over a bed of Laurentian gneiss which it has not worn sufficiently even to obliterate the well defined glacial striae that may be seen on almost any of the rocks along its shore. It is, however, enlarging and deepening its channel by cutting away the alluvial point lying to the west of it, on which the store-house of the Hudson Bay Company is at present situated. This point, which stretches as a long narrow arm between Winnipeg and Playgreen Lakes is also being rapidly worn away by the waves of both these lakes, and the time is not very remote when the site of the present narrow arm of alluvial clay and peat will be at the bottom of the united lakes.

"A deposit of clay similar to that on Mossy Point extends all along the east shore of Lake Winnipeg, and the waves washing against the soft cliffs become charged with the mud from which the lake derives its name.

"This clay is also of great economic interest, for instead of the east shore of the lake being an uninhabitable rocky wilderness, as is generally supposed, it is largely covered with a rich blue alluvial soil, and the area of rock surface is relatively small. Much of this land is covered with forests of poplar and spruce, while on account of the retentive impervious nature of the clay soil much of it is also boggy and wet, but when it is cleared and drained it will form rich agricultural land. At Bad Throat River, Mr. Wood, the local Inspector of Fisheries, had cleared a beautiful farm out of the midst of the poplar forest, and he informs me that he grows successfully all the crops ordinarily raised in Ontario. Mr. McKay, the Indian Agent at Berens River, has also a clearing situated on the south side of the river in the midst of what was a dense forest of small spruce. He has under cultivation a nice garden, and this year the potatoes were not cut down by frost till the middle of September.

"On the evening of the 1st of September, we pitched our tents near Warren's Landing, beside that of the Mounted Police lake-patrol, under my old college friend, Mr. H. E. Morphy. He was travelling

in an excellent yacht built by Matthew Watts, of West Selkirk, who was employed on it at the time in the capacity of skipper.

"On the following morning we rowed to the east shore of the lake and travelled along it without interruption until Wednesday evening, when we camped in the mouth of a small creek south of Spider Island Point. The same evening we saw the police yacht sail into the harbour of Spider Islands. On Thursday a heavy storm set in from the north-west and we were unable to move from the mouth of the little creek till about sunset, when taking advantage of a lull in the tempest we sailed across to Spider Islands and again camped beside the police detachment. On Friday the gale continued with redoubled fury, and the day was spent in closely examining the small island of gneiss on which we were forced to remain, and photographs were taken of the camp and of the surrounding rocks. About sunset the wind fell and we at once furled our tents and ran to the mouth of Little Black River, three miles distant, where we remained for the night.

"On Saturday morning the weather was beautifully clear with a light air blowing from the north-west, and as I walked along the sandy beach I saw the ill-fated police yacht sail out from Spider Islands and disappear in the distance towards the south-west. That afternoon a very heavy storm of rain and north-west wind set in and continued throughout the night, and before morning the police yacht had struck on a reef off Pigeon Point and gone over on her side. The two policemen were drowned, but Matthew Watts, the skipper, lashed himself to the side of the boat and, twelve days later, was taken off by some passing Indians.

"Sunday was still dark and rainy, with a high wind from the north-west, but on Monday, the 8th of September, we continued southward along the shore, and on Friday, the 12th, reached Berens River, where we camped beside the Hudson Bay Co.'s trading post. For most of the distance from Nelson River I had travelled on foot along the beach, while the boat followed as near the shore as the many reefs would allow. The rock was everywhere found to be Laurentian gneiss without any constant dip or strike. It was also found to be strongly glaciated, and in several places two sets of striae could be clearly recognized. It was generally covered by the soft blue imperfectly stratified alluvial clay mentioned above.

"At Berens River inclement weather detained us for several days, and during this time we were indebted to Mr. Angus McKay, Indian Agent, for continued hospitality. On Tuesday evening, the 16th of September, the Rev. Mr. Butler, Methodist Missionary, informed me

that a skiff had been found by an Indian on the shore, but it was not till the following evening that we ascertained that this was the tender of the police yacht, and that a boat and last had also been found on which was written the name of one of the unfortunate policemen.

"The next morning, the 18th of September, we started before day-break, and ran out to Pigeon Point, followed by Mr. Angus McKay, and examined the shore closely from Pigeon Point southward to the mouth of Catfish River, but a heavy gale striking us, we were unable to take our boats more than four miles south of Pigeon Point. About three miles south of this point the first wreckage was found, and from this place southward for three-quarters of a mile to a prominent point, which might be called Police Point, light wreckage, such as pine boxes, etc., was scattered on the beach, much of it several feet above the level of the water. On the south side of Police Point, no wreckage was found, but from the bottom of the next bay to Catfish Point, heavier pieces of wood, such as oars, etc., were discovered, often half buried in the sand, having evidently been thrown on the beach by a heavy north-west wind.

"The next day was beautifully calm, and Mr. McKay proceeded along the shore in his canoe to Flower Point, while we examined the reefs and islands between Swampy Island and the main land. We also left a letter with Mr. Plunkett at the lighthouse, near Swampy Island, to be forwarded as soon as possible to Hon. John Schultz, Lieutenant-Governor of Manitoba, informing him of the probable wreck of the police yacht '*Keewatin*' No trace of a wreck was to be seen on any of the reefs or islands, but Mr. McKay found further signs of wreck on the shore, but up to that time we had not found the boat itself.

"Friday night was spent at Flathead Point, and on Saturday a heavy wind blew from the south, so that we were unable to proceed. On that evening, however, several Indians arrived from the south, and informed us that they had found a large sail boat, with an old man lashed to its side, lying on the beach between Flower and Rabbit Points; that the old man had been taken care of, and brought to a house on Rabbit Point, and that the boat had been righted and taken into a harbour. Also that the old man, Matthew Watts, had told him that his two companions had fallen off the side of the boat several days before.

"Nothing further could be done, therefore, for the ill-fated policemen, and as the stormy weather presented every appearance of continuing for some time, I decided to leave the great northern expansion of the lake, and to run at once to Dog's Head, and work southward in the less open water south of the narrows.

"From the point east of Dog's Head the east shore was closely followed most of the way on foot, to the mouth of the southern Black River, and at the same time Black Island and many of the adjoining smaller islands were also examined. This proved to be much the most interesting part of the lake, as the shore from Dog's Head to Loon Strait was found to consist of altered gneisses and quartzites with a regular and long continued strike down the shore, having quite a distinct field appearance from the Laurentian gneiss further north. These rocks continue along the shore for a short distance south of Loon Strait and are then gradually replaced or overlaid by green quartz porphyries possibly of the Keewatin series. In a group of islands lying off Delay Point and north-east from Big Grindstone Point this quartz porphyry island is well seen in the eastern members of the group, while the most south-westerly island is conspicuously high and wooded and was found to be composed of massive green soft serpentinous rock, through which are running many veins of magnetic iron ore.

"Black Island was found to be composed of dark green schistose or massive chloritic rock which in the bottom of Hole Bay was found to present a sharp line of contact with the quartz porphyries. Overlying these schists is a considerable thickness of Palaeozoic sandstones, apparently of the age of the Chazy ('St. Peter's Sandstone') of Minnesota, which at the south-west end of the island are found to run up conformably into the Trenton limestone.

"This sandstone evidently extends northward as the basal formation of the Palaeozoic and the basin of Lake Winnipeg has been largely eroded out of its soft and easily disintegrated beds.

"From Black Island the supposed Keewatin rocks were followed round the bottom of Hole Bay, to near the mouth of Bad Throat River, where they suddenly end, and the shore is found to be composed of dark gray micaceous schists and light reddish gray granites, which are thence found to continue at least as far south as Black River.

'From Black River we crossed to the south of Red River and reached Selkirk just as the first heavy snow storm of the season set in. Here I learned that Mr. Dowling had arrived in from the lake a few days earlier. The following is his account of the work done by him during the summer:—

'I left Winnipeg on the 10th of June, and proceeded to Minnedosa, stopping at Westbourne to ship the large boat and camp outfit, stored here last year, to Selkirk. At Minnedosa a team was hired, and we proceeded northward on the trail known as the "Dauphin Road." For twenty miles we passed through a well settled country, and the road was well beaten, but from Scandinavia north it runs through

bush, following a meridian township line in to the settlement at Lake Dauphin. From Minnedosa, 1,670 feet above the sea level, the mountain rises gradually to 2,300 feet above sea, the trail then descending the northern slope into the valley of the Ochre River, 1,000 feet below. The top of the mountain is covered by a series of morainic hills, and the trail following a meridian line is forced over hills that otherwise might have been avoided.

Having completed our observations in this district, I returned to Minnedosa and thence to Selkirk, where supplies and men were obtained for the summer work on the islands of Lake Winnipeg.

Leaving Selkirk on the 28th of June, we proceeded north to Punk Island, where our work commenced. This island and Deer Island were traversed along their shores, the measurements being made with a patent floating log, and the position of the islands fixed by bearings taken from known points on the main shore.

North of Dog Head, in Fisher Bay, are several large islands, which were surveyed, and the rock exposures examined, and a collection of fossils made.

On the 25th of July, Mr. Lambe, of the Palaeontological branch, joined our party for a month, and aided materially in making our collection of fossils more comprehensive.

Berens Island and the bars and islands south of it were all traversed, and the month of September was spent among the islands on the west side of the lake between the mouth of the Little Saskatchewan and Long Point. Reindeer Island which has not been shown on any map, was found to be twenty miles long and five miles wide.

Soundings were taken whenever practicable and noted, more particularly in the shoaler parts.

Observations for latitude were taken at the following places: Cat Head, mouth of Little Saskatchewan, north end of Reindeer Island, south-east side of Reindeer Island, Fishing Station, Berens Island and at Berens River Post. Owing to the delay occasioned by the many storms during the season, the northern part of the lake was not visited, and we returned to Selkirk on the 8th of October.'

At Selkirk the goods and smaller boat were stored in the warehouse of the North-west Navigation Company, and the larger boat was left in charge of Messrs. Wright and Howell, and on the 16th of October we left for the east.

"During the season eighty-three photographs were taken of points of especial geological and economical interest."

Cost of season's exploration, \$1,976.59.

Mr. McInnes left Ottawa on the 5th of June for the purpose of continuing the work previously carried on by Dr. A. C. Lawson, in the districts of Rainy Lake and Thunder Bay. He was joined at Toronto by Mr. Smith, with his assistant, Mr. Lawson, and by Mr. Thos. Wiggins, of Napanee, who was appointed assistant for the season's field work.

A summary of Mr. Smith's work is appended.

Mr. McInnes reports as follows :—

"The party arrived at Port Arthur on the 9th of June. Some difficulty was experienced there in obtaining canoeemen, who were in great demand on account of the activity of prospecting and surveying work in the district. Very good men were, however, eventually obtained from Rat Portage, through the kindness of Mr. Alex. Matheson, of the Hudson Bay Co., and were sent to Wabigoon Tank, on the Canadian Pacific railway, whence a start was made, on the 17th of June, southward on the Manitou route. This route follows a chain of lakes and waterways to Manitou Lake, and, still southerly, through this long, narrow lake to Rainy Lake. The valley occupied by this chain of lakes lies altogether in Huronian (Keewatin) strata. The long, narrow shapes assumed by the lakes being determined by the trend of the schists whose strike is followed in a remarkable way by the contours of the lakes. This feature which Dr. Lawson speaks of (p. 17, Part F, An. Rep. Geol. Survey, Vol. III.) is a very striking one, and characterises not alone this route but all the great water routes of the region. It seems to be due to the greater readiness with which the calcareous beds of the Huronian give way under denuding agencies. The valleys on these routes, generally narrow, are often of great depth ; narrow lakes, less than one mile in width, will frequently show a depth of more than 200 feet. Some of those belonging to a chain running north from the Seine River were found by Mr. Smith to be very remarkable in this respect, and soundings in Dog Lake gave a very uniform depth of from 180 to 220 feet.

"Rainy Lake was followed southerly to its south-westerly corner at Fort Francis, and thence easterly to the north of Seine River. This traverse led through the centre of the Rainy Lake sheet already published, and afforded an opportunity of proving the immense advantage to one travelling through the district of so carefully compiled a map as the one here referred to.

"From Rainy Lake the Seine River was followed upwards to Lac des Mille Lacs. From this lake the Kaministiquia River was reached by way of Lakes Kashabowie Shebandowan and the Matawin River

"The Kaministiquia River was followed to Port Arthur and the re-

mainder of the season devoted to an examination of the Dog Lake region and to a micrometer survey of Greenwater Lake—a large lake hitherto unsurveyed, which lies south of Shebandowan and which flows into that lake.

"In general character the region is a rolling country of low hills, generally well rounded and glaciated, and often with a surface almost bare of soil. It is exceedingly well watered—a district of lakes and watercourses which afford ingress to it, and by means of which intercourse is carried on through it in every direction.

"The rocks of the region under consideration may be divided into the two great divisions of Laurentian and Huronian. The former, chiefly gneisses and granitoid gneisses, occur in detached areas and bands, which are surrounded on all sides by Huronian (Keewatin) rocks. Only in the south-western part of the Aticokan sheet were rocks noticed which seem referable to Lawson's Couthiching series. Everywhere else the Huronian is represented by the so-called Keewatin series, consisting largely of trappean material, sometimes massive, but often with a schistosity developed by pressure. There is, however, in addition to the trappean beds mentioned, a considerable amount of clastic strata—of conglomerates, altered argillites and quartzites, generally calcareous. The quartzites, alternating with thin bands of limestone, are in places shattered, and re-cemented by calcite.

"Considerable activity was shown in prospecting in the district during the past summer, and the iron-bearing area of the Aticokan River is already largely taken up.

"The reports from many of the mines in the silver-bearing Animikie series to the south were very encouraging and the completion of the Port Arthur and Duluth railway through the silver districts will afford the outlet so long needed by these mines, and will enable them to carry on their work to much greater advantage.

"Although the district as a whole cannot be called a good agricultural one, there are in it numerous areas of good lands suitable for cultivation. Some good red pine was noticed at different points, though for the most part it is scattered and poor. That seen around some of the lakes connected with the Seine River could be driven down that river to Rainy Lake and thence to Rat Portage.

"During the season about 400 miles of lakes and streams were surveyed by prismatic compass and boat-log, and by estimated distances, and 40 miles by micrometer telescope. In addition to the above, traverses were made during the summer for the purpose of examining the region geologically, where no surveys were necessary."

Mr. Smith left Ottawa for the field on the 3rd of June and was joined in Toronto by Mr. William Lawson, his assistant. On their arrival at Port Arthur, a few days were occupied in procuring supplies and equipment, and some delay was caused in securing suitable men.

The party with Mr. Smith left Savanne on the 14th of June, and the first seven weeks were occupied in making micrometer and compass surveys of a chain of lakes, which extends from Clearwater Lake, on the Seine River, to Little Wabigoon River ; of the Eye River route, connecting the latter with Seine River ; in a partial survey of a chain of lakes hitherto unknown, which extends from Clear Lake, on the Wabigoon route above mentioned, to the Big Turtle River ; and in a partial survey of the upperlacustrine expansions of the Seine River.

The second trip, of three weeks' duration, was occupied in making a micrometer and compass survey of the upper part of the Seine River from its junction with the Fire Steel River to the entrance of Partridge River ; of the Brush Creek route to English River on the Canadian Pacific railway, and partially of the Partridge Lake route to Lac des Mille Lacs.

At Savanne four days were lost through bad weather and delay in securing men to replace those who had left, and on the 30th of August the party left Savanne, travelled down the Dawson route to Windigongstigwan Lake, thence through Crooked Pine Lake and down the Aticokan River, finishing surveys of some short routes running northward which afforded sections across the Keewatin belt of rocks here traversed ; thence down the Seine River, completing the surveys of the last season, to within eight miles of Sturgeon Falls. Here the party was divided, Mr. Lawson returned up the Seine River, and completed all the unfinished topography on this route to the eastern boundary of the sheet, while Mr. Smith, with one man and a light canoe, passed by a winter route across the headwaters of the Little Turtle River, and thus gained another section across the northern limit of the Seine River Band of Keewatin rocks ; passing by this route into the chain of lakes explored in the earlier part of the season, he finished the surveys west to the Turtle River and east to Clearwater Lake. Thence he descended the Seine River to the next lake south, and then passed through a chain of small lakes running easterly to the old Indian Reserve No. 23 on the first expansion down the Seine River. He then proceeded to Savanne, *via* the Partridge Lake route, and arrived there on the 4th of October, the day after Mr. Lawson.

The band of Keewatin rocks shown on the "Rainy Lake sheet" as following up the Seine River, as far as the eastern limit of the map, has been traced all the way up the river in somewhat broader development as far as Steep Rock Lake. Here the band bifurcates the

northern portion, strikes N.N.E. and skirts the N.W. side of Clearwater Lake, with a width of three miles. Thence it curves to the N.E. and E., crosses the Brush Creek route, with its southern boundary on First Lake and its northern boundary on Pyramid Lake, and is again seen at the first falls up the Fire Steel River, where its strike is a little south of east.

The other band, varying in width from four to seven miles, passes in a general easterly direction up the Aticokan River, encompasses Crooked Pine Lake, and the north-western and north-eastern arms of Elbow Lake, and it is again seen on Baril Bay of Lac des Mille Laes. The iron ores of the Aticokan and Whiskey Jack rivers are found in this band, and iron ores have also been found below the bifurcation of the band on the Seine River. The "Star Island" gold location is in a spur from this band which outcrops on Partridge Lake.

Between the bands and to the northward the country is entirely occupied by Laurentian gneisses and granites.

The broad band of Cutchiching mica schists so extensively developed on Rainy Lake, extends into the country shown on the south-western part of this sheet, but a few miles from its western boundary they are replaced by and interbanded with gneiss, which, as we proceed eastward, becomes the predominant rock, holding narrow bands of mica schists, which become less frequent further to the east. But this characteristic of the rocks is fairly constant throughout the whole of the gneissic area embraced in the southern portion of the Seine River sheet.

The work of the season was somewhat scattered and isolated, and an unusual amount of time was lost through wet weather.

The topography of the Seine River sheet has, however, now been completed, and all the accessible lakes in an area of about 1,600 square miles accurately outlined. About 300 miles of compass and micrometer lines, 250 miles of log and compass lines, and 50 miles of time traverses were run, serving as base lines for the compass triangulation of islands and intermediate points.

In addition careful notes were taken of all rock exposures, on the lake shores and on the rivers, from which the geographical distribution of the several bands can be accurately mapped.

Mr. McInnes returned to Ottawa on the 30th of September, and Mr. Smith on the 30th of October.

The cost of the season's work and pay of assistants was \$2,556.13.

Dr. Bell was again engaged in the vicinity of Sudbury, working out the details of the structure, and studying the affinities, mode of occurrence and associations of the very interesting rocks with which the nickel, copper and other economic minerals of this district are associated. The subdivisions and their geographical distribution will now be shown on a map, scale four miles to one inch, covering an area of 3,456 square miles around Sudbury. This map is now nearly ready for the engraver. It will be sheet No. 130 of the projected series of the geological maps of Ontario, and will accompany and illustrate Dr. Bell's detailed report of his investigations in the great Sudbury Huronian belt during the seasons of 1887-88-89.

Mr. A. E. Barlow, as during the seasons of 1887, 1888 and 1889, assisted Dr. Bell in both the geological examinations and in the topographical measurements.

Mr. Barlow left Ottawa for the field on the 8th of July and returned on the 27th of September. Dr. Bell left on the 15th of July and returned on the 30th of October.

Three students, Messrs. A. M. Campbell, H. H. Walker of McGill College and T. L. Walker of Queen's, were attached to the party, and H. Skill and D. McLaren were engaged as canoe men and general assistants.

Dr. Bell reports on the work as follows:—

"Most of my time was occupied in the northern, central and western portions of the district represented on the map, while Mr. Barlow worked principally on the south-eastern half of the Huronian belt which traverses it. The work of both consisted largely in tracing out more closely the limits of the lithological divisions of the Huronian system and in ascertaining more details respecting the Laurentian. Special study was given to the geological relations of the nickel and copper deposits. Incidentally to these investigations, a good deal of topographical surveying required to be done.

"For the purpose of delineating more accurately the outlines of Lake Wahnapitæ and connecting it with the towns to the westward, I re-surveyed its western side, and the lakes and portages thence to the Vermilion River, and also made a micrometer survey of this river from the point reached by Mr. Barlow last year to a position beyond Proudfoot's east and west line. In connection with this survey, fourteen traverses, each occupying one or two days, were made to the right and left of the Vermilion River as a base. Other explorations were also undertaken in the Laurentian country between the Onaping and Vermilion rivers, in the townships of Morgan, Levack and Lumsden, and between these and Proudfoot's base line. Besides

these a track survey was made of seven lakes lying eastward of Wahnapitæ Lake, the largest of which (Koo-ka-ga-ming) is nine miles long. Some additional geological work was done in the Geneva Lake Huronian outlier, which is first entered upon by the Canadian Pacific railway at a distance of thirty-three miles north-west of Sudbury. Mr. Barlow re-surveyed Ramsay Lake and some smaller bodies of water in the townships of McKim, Garson, Blezard and Snider. Surveys were likewise made of the roads which have been lately opened in the townships of McKim and Snider, Sudbury district, and also of the Emery Lumber Company's railway north-westward from Wahnapitæ station, in the township of Dryden.

"The following are among the geological results of the season's operations: The numerous exposures of gneiss and red quartz-syenite between the Wahnapitæ road and the township of Denison have been traced out and connected together, showing that they all belong to a continuous range of these rocks lying in the centre of this part of the Sudbury trough. It was found impossible to separate on the map the gneiss and quartz-syenite of this range or of the main body of these rocks on the northern west side of the trough. An area of fine-grained, dark gray varieties of imperfect gneiss and quartz-syenite occurs around Wia-shai-gaming (or 'Fairbank') Lake, which connects this central range of the ordinary gneiss and quartz-syenite with the great area of these rocks on the north-west.

"A long and rather narrow mass of coarsely crystalline gray diabase was traced from Whitson Lake south-westward into the township of Denison, a distance of twenty-four miles. This cuts off a narrow belt all along the south-eastern side of the central range of gneiss and quartz-syenite. It is about a mile wide in the middle and runs to a point in either direction. The ore deposits of the following properties are situated along the south-eastern side of this mass or in the continuation of its course: Waddle's, the Dominion mine, Russell's, Stobie's, Murray mine, McConnell mine (in Snider), Lockerby and McIntyre's, lot 10, range I., Snider; the Crean or McConnell mine and the "Mineral Range," in Denison. The ores of the Stobie, Copper Cliff, Evans, lot 12, range 3, Graham, and the Vermilion mine, are associated with diorite, mostly brecciated, along the south-eastern or opposite side of the belt of gneiss and quartz-syenite which is cut off by this mass. Its confused character and the great number of angular fragments and masses of other rocks which it contains would indicate that we have here another line of ancient volcanic disturbance.

"A second mass of crystalline, gray diabase, similar to that of the first one which has been described, was traced from the north-eastern

part of the township of Levack south-westward for a distance of eighteen miles. This one is also about one mile wide in the centre and has the same form and course as the other. Several deposits of the nickeliferous pyrrhotite have been found on its course. Numerous masses of green crystalline diorite occur within the area chiefly occupied by the quartzite and greywacke series, and at the contact of these with the adjacent rocks several promising deposits of similar ores have been discovered.

"In regard to the stratigraphy of the district, the Sudbury Huronian trough, where it is traversed by the line of the Canadian Pacific railway, has a width of twenty-four miles. The Geneva Lake outlier has a breadth of seven and that of Onaping Lake of three miles. In the main or Sudbury trough the rocks on either side dip at high angles towards the centre. The lowest member is the quartzite and quartzose greywacke series, which prevails all along the south-eastern side from the southern border of the sheet at Lake Panache as far as the Wahnapitæ River, beyond which it becomes rapidly more argillaceous and spreads out over a wider geographical area.

"The green diorite masses in the midst of the quartzite and greywacke series vary in length from half a mile to ten miles, and as a rule, their longer diameters conform approximately with the prevailing strike of the surrounding rocks. On the north-west side of the trough this series is represented by a band of gray quartzite containing scattered pebbles of white quartz. This quartzite is overlaid by the remarkable black breccia referred to in last year's summary report. It appears to be several thousand feet thick, and was traced from Vermilion Lake north-eastward to a point on the upper Vermilion River beyond the latitude of Lake Wahnapitæ. Professor G. H. Williams, to whom specimens of the Sudbury series of rocks were sent for microscopical examination, has found that the irregular white spots with which this rock is flecked were originally fragments of pumice, but that they have been entirely replaced by silica.

"The highest member of the Huronian series in the district consists of thick gray argillaceous sandstones or greywackes, interstratified with more argillaceous bands. These rocks occupy a large tract of country between Vermilion Lake, in the township of Fairbank, and Lake Wahnapitæ, and generally dip at moderate angles."

The cost of the season's operations was \$1,746.64.

The strata above referred to by Dr. Bell as the highest member of the Huronian resemble very closely the rocks known as the whin series in Nova Scotia, as they do also the Lower Cambrian (Harlech and Llanberis grits of North Wales).

Mr. A. S. Cochrane was again engaged in topographical work in the Ontario peninsula. He left Ottawa on the 23rd of July and returned on the 18th of October. His work was similar to that of previous years, and consisted in mapping the streams, hill features, etc., more correctly than they had been hitherto represented on the township plans. These plans are from the original surveys, which were made when the country was all under the primitive forest, and at that time the contours of the smaller hills could not be seen and the streams could only be noted where they intersected the concession and sidelines. As stated last year, the swamps, which existed while the country was in a state of nature, have been drained and have to a great extent dried up since the land has been cleared, so that in this respect the original maps do not correctly represent the country. In 1889, Mr. Cochrane had finished sheet number 115 and the past season he commenced on sheet 107, which is the next one to the south. He completed the topographical details in the townships of Kincardine, Huron, Kinloss and part of Greenock, which lie in the north-western corner of this sheet. In sketching in the above features Mr. Cochrane was guided by the lot lines, which are marked by boundary fences or by odometer measurements. The heights were determined by aneroid barometer.

Except near the shore of Lake Huron, where sand and gravel prevail and the surface is level, the townships examined are underlaid by a great depth of bluish-gray stone clay, with brown clay sometimes resting upon it; the surface being undulating and usually overspread by a rich loamy soil.

The fundamental rock was found in only one place, namely, about three miles east of the town of Kincardine, where a flat layer of gray limestone was exposed for several hundred feet in the bed of a branch of the Penetangore River. Some fossils were collected here which Mr. Whiteaves states belong to the Corniferous formation which had been already represented as occurring at this locality upon the geological map of the province.

Cost of this field-work, \$350.

During the past summer Dr. Ells, assisted by Mr. Giroux, was occupied in continuing and extending the work of the previous season within the limits of the south-west quarter sheet of the Eastern Townships map. His own attention was devoted to a more careful and detailed examination of the area between the Grand Trunk railway and the Vermont boundary and between Memphremagog Lake and the Richelieu River, while the northern or St. Francis River area was

studied by Mr. Giroux, whose work included a careful examination of the section exposed down that river and up the Yamaska to St. Hyacinthe. Respecting these examinations, Dr. Ells states as follows :—

“ Large collections of fossils from a number of points were obtained, in which work I was ably assisted by Mr. W. E. Deeks, B.A. Toward the latter part of the season, a few days were spent with Mr. C. D. Walcott, of the United States Geological Survey, in the study of the rocks about Philipsburg, Mystic and Highgate, in order to determine more accurately the exact horizon of the Philipsburg and Stanbridge series. Upon the setting in of bad weather in October, the rest of the season was devoted to the examination of the copper and asbestos mines of Sherbrooke, Thetford and Black Lake.

“ While the surveys of the past season have not yet been fully plotted out, sufficient has been done to determine, with the aid of the fossils collected, the stratigraphical sequence and boundaries of the several formations east of the great St. Lawrence and Champlain fault. The black limestones of Farnham, which were supposed in 1863 to underlie the Levis formation, were found, as was pointed out in 1877 to be of Trenton age, as indeed the list of fossils, see pp. 239, 240 Geology of Canada, 1863, very clearly indicates. The stratigraphical sequence embraces, from the Cambrian through the Calciferous and Chazy to the Farnham limestones, which certainly represent a portion of the Trenton formation, the underlying Chazy being seen both to the east and west. Thus the Farnham rocks occupy the centre of a synclinal instead of the crest of an anticlinal, as supposed in 1863.

“ The lowest rocks of the series, west of the Sutton Mountain pre-Cambrian and Cambrian strata, are the red and green slates and sandstones which constitute the prominent ridge of Granby, and which extend south-westerly almost to the line of the Canadian Pacific railway east of Farnham station, and also occupy the country between Granby and Abbotsford up to the great St. Lawrence and Champlain fault, which passes immediately to the west of Yamaska Mountain.

“ The black Trenton limestones of Farnham centre do not appear to reach the Vermont boundary, the underlying Chazy limestone and dolomitic shales coming to the surface in this direction in a basin-shaped synclinal whose depression is to the north-east; but northward they can be traced continuously east of Granby and Roxton to and across the St. Francis to the Danville and Arthabasca areas.

“ The country west of the St. Lawrence and Champlain fault is generally level, broken only by the intrusive masses of Rougemont, St. Hilaire, Mount Johnson, Monnoir, and kindred mountains. There

are very few rock exposures in this level country. Some outcrops which occur at Chambly, St. Jean Baptiste and St. Hyacinthe have yielded a numerous list of fossils; they have not yet been determined, but appear to indicate that the rock over the greater part of the area belongs to the Utica and Lorraine formations, as they are described in the Geology of Canada, 1863.

"The slaty belts on either side of the Central Anticlinal axis of Sutton Mountain, referred to in the Summary Report last year (1889) were traced for seventy-five miles, and the complicated relations of the rocks between these slaty belts and Lake Memphremagog were carefully examined. A complete micrometer survey of the lake on the Canadian side was made, and the intricate mixture of Silurian and Cambro-Silurian fossiliferous rocks, cut in places by very peculiar, often sheared dykes, clearly mapped out.

"The mining interests of the townships, though for the most part within the area adjoining that contained in the field of work just described, are on the increase. Two new copper mines in the Sherbrooke belt of schists, the Moulton Hill and the Howard, have been opened, and are now shipping ore to a considerable extent. The ore is very similar to that found at the Capelton mines, and, like that, is used for the manufacture of sulphuric acid. The copper contents of the lode apparently increase as the veins or lodes are opened downward. Further development, on properties abandoned some years ago in the district near Sherbrooke, are about to be undertaken; and the Huntington mine, lately acquired by Messrs. G. H. Nichols & Co., has been pumped out and mining operations resumed.

"The asbestos industry shows also a great increase, both in the amount of the output and in the prices obtained for the raw material, and probably not less than 8,000 tons have been shipped during 1890, though the complete returns are not yet in. The price of No. 1 has risen rapidly from \$100 to \$125 to \$200, and even \$250 per ton, with a further tendency upward. Several new mines have been opened and the work at the old mines has been pushed with greater vigour. The increase in the output is largely due to the fact that improved machinery is now employed in all the pits, in some of which compressed air for the purposes of drilling and hoisting is used; others use steam direct, the former being considered the more advantageous, owing to the ease with which the drill holes can be kept clean. Preparations are now being made for removing the dumps from their present sites to the barren ground near the Thetford River, and it is estimated that the crushing and cribbing of these will amply repay the cost of removal. The necessity of employing machinery for the purposes of crushing and

cobbing for the smaller veins at least is now recognized, and is being put in operation at the American and Anglo-Canadian mines at Black Lake. In addition to the mines already described in former reports, several new areas have been opened on the west side of the Quebec Central railway. While the veins at all these occasionally show good fibre, it is evident, upon examination, that the rock nearer the river and on the low ground does not yield such fine asbestos as in the mound where the mines were first opened. In Coleraine, also, several of the new companies which began operations last year at Black Lake have abandoned their locations, owing, probably, to an unfortunate choice of ground, while some of the Thetford companies—notably King Bros., A. S. Johnston and A. H. Murphy—have opened new areas here and found good veins. Among others, Dr. James Reed, on lots 27, 28, 29, has erected a first-class mining plant, with air compressors, for carrying on work on his areas, on which considerable work has been done during the past season, mostly by the contract system.

“On the west side of the upper part of Black Lake, near the inland line, Messrs. Grundy, Steel & Co., of the Beaver Mining Company, have begun work in Range B, Coleraine, but the work so far has been mostly exploratory. Numerous small veins and some of fair size have been found, but their value cannot yet be definitely pronounced upon.

“Great activity on the part of prospectors is manifested throughout the whole of the Serpentine belt of Thetford, Coleraine, Broughton and Wolfestown. Several finds of valuable areas are reported, none of which, however, in so far as careful inquiry could determine, are of very great importance.

“An interesting point discovered during the past year is the fact that the walls of so-called barren rocks encountered in nearly all the mines, owing to the presence of faults, and formerly supposed to be worthless, are now in good ground, the barren portions extending but a short distance. This is what might have been expected in such areas, the fault being only local and merely displacing masses of presumably equally rich serpentine.

“The serpentine areas of the south-western portions of the province have not yet disclosed the presence of workable veins of asbestos in quantity, with the exception of the mine at Danville, owned by Mr. Jeffrey, where some fine veins have lately been discovered. The Brompton Lake mine, which is the most southerly, worked to any extent, has been opened to a very considerable depth, and a large amount of money has been spent; but the prospects for workable veins in the lower workings are no better than at the surface, and no returns have yet been made. About Orford Pond on the south side of Orford Mountain,

and near Long Lake, at the northern extremity of the same ridge, excavations have been made in thin and irregular seams a fourth of an inch, and in the road west from Knowlton Landing to Bolton Pass, in the serpentine band to the east of the Missisquoi River, some exploratory work has been done without finding asbestos of any economic value, and in so far as yet ascertained this portion of the province does not present favourable indications for profitable asbestos mining.

"Of the work of the assistants in the field, Mr. N. J. Giroux, C.E., and W. E. Deeks, B.A., I can speak in the highest terms."

The party left Ottawa on the 11th of June and returned on the 11th of October.

Expenditure for the season, \$1,490.

During the months of July and August the Rev. Abbé Laflamme, at my request, made some geological investigations in the county of Charlevoix, on which he furnishes the following report :—

"Attention has been more especially directed to the study of the Cambro-Silurian deposits on the north shore of the St. Lawrence, in the county of Charlevoix. The valleys of the Rivière du Goufre and of the Malbaie River are almost entirely occupied by limestones, extending in the first of these, to about ten miles from the St. Lawrence, and forming a band of nearly uniform width all through that distance, except at Cape Martin, where the outcrop of the calcareous strata, measured transversely to its direction, is notably narrower.

"In the Malbaie River valley the limestones disappear at a point nearer to the St. Lawrence, or at most seven or eight miles from it, but the area they occupy is considerably wider than on the River Goufre. Other limestone areas occur in the valleys of the Petit Lac and Lake Nairnes.

"Except in a very few places, it has been found totally impossible to trace with certainty the limits of the calcareous beds, the drift deposits which fill those valleys being so thick as to utterly prevent any such determinations, especially along the upper parts of the above-mentioned rivers.

"There are no Cambro-Silurian beds in the narrow valleys of the other streams of Charlevoix county, such as the Little Malbaie River and the numerous creeks falling into the St. Lawrence between St. Irénée and Baie St. Paul.

"The calcareous strata in both the large valleys referred to are only slightly disturbed. They generally take the shape of a broad synclinal, with only a few secondary folds.

"Other conditions obtain in the Cambro-Silurian band along the shore of the St. Lawrence, between Gros Ruisseau and Point Pères, and from Cape Martin to one mile above the wharf at Eboulements. This band is narrow from one end to the other, its maximum width being little more than a mile. It is not continuous, as shown on the map sent me from Ottawa last spring, but is interrupted for a long distance between Cape Martin and Point Pères, the only trace of it to be found in this distance being some unimportant and isolated knolls on the shore of Apple Cove (Anse aux Pommes).

"All the beds dip at a very high angle, mostly towards the St. Lawrence River. At points where they have not been too much disturbed there appear, both above and below, and lying conformably with them, beds of quartzite, frequently cut by large felspathic veins, of a pink colour, and apparently of Archæan age.

"Fossils are scarce in the basins of the Goufre and Malbaie Rivers, but they are plentiful at the mouth of the latter stream, especially along the line of contact of the limestone and sandstone beds which, with a thickness of a hundred feet, here constitute the base of the Trenton series.

"This great deposit of sandstone forms a building stone of excellent quality. The rock is cream-coloured in the upper part and becomes light green at the base of the series ; it can be quarried in blocks of any dimension. The material in the top beds is hard, fine-grained and is but slightly affected by exposure, being in consequence very well adapted for pavements. In fact, a large quantity is extracted every year for this purpose.

"There are but few economic minerals in Charlevoix county. In addition to the limestones and sandstones above referred to there may be found here rocks holding a large quantity of garnets, notably at St. Iréné and Malbaie. At the first mentioned place these garnets are very large, being frequently over six inches in diameter, but all are fissured and of no value. At Malbaie on the shore one mile above the wharf, the crystals are smaller, but their colour is better and their brightness greater than at St. Iréné.

"I have also visited the deposit of titanic iron ore at St. Urbain, but notwithstanding a careful examination of the place, its actual limits could not be defined, on account of the thickness of the drift there. One thing, however, is certain and that is that the quantity of titanic iron ore in the deposit is practically unlimited. The part already opened is immense, and many other similar deposits may be seen in various places.

"The iron works, formerly erected by an English company which, it is said, spent half a million of dollars on the spot, are totally ruined, there being only left to mark their site a few piles of old bricks, and the same must be said of the tramway which connected the mine with the village of Baie St. Paul, on the shore of the St. Lawrence.

"The silver mine which it is was alleged had been worked by the French and had been re-discovered recently never had any existence, except in the fancy of those interested in the selling of the property; and the galena veins on the west side of Baie St. Paul are so small and carry so little of the mineral that they are totally worthless. The alleged phosphate mines of St. Iréné are nothing but veinlets of sandstone imbedded in Archæan rocks and carrying fluorspar.

"It has been reported that asbestos and mica had been found at a point a few leagues distant, north-west of the St. Lawrence, but the truth of the report has not been ascertained and it should not be lightly credited."

The first description of these limestone areas was given in the Geology of Canada, 1863, Chap. IX., pp. 160-163.

Cost of exploration, \$400.

Mr. A. P. Low was engaged during the past season on an exploration of the region around Lake St. John, in continuation of the work previously undertaken there by Mr. F. D. Adams and the Rev. Professor Laflamme. Respecting this work Mr. Low states:—

"The party left Ottawa on the 28th of May, and after spending ten days in Quebec copying plans of surveys in the district the work was commenced at Lake Edward. A complete geological examination was made of its shores and of the Jeannotte and Batiscan rivers, flowing out of it, to Laurentides Station on the line of the Quebec and Lake St. John railway.

"Along the southern shores of Lake Edward and on the upper part of the Jeannotte River a dark greenish, basic, dioritic gneiss occurs; this rock is highly impregnated with iron ore, usually occurring in the form of small grains, but frequently in masses several inches in diameter, and probably may be found in larger quantities and be of economic value. These dark basic rocks are also seen along the shores of Lake Batiscan and its outlet, also on the line of the Quebec and Lake St. John railway, to the north of Lake Edward.

"Having completed the exploration of the Batiscan valley, a canoe route from the headwaters of the Rat River was followed through Lake Najalouyand, on the Bostonnais branch of the St. Maurice, thence

across the height of land through Lakes Doré, Ecarté, Ouaquagamasis, Commissaires and Bouchette to the mouth of the Ouiatchouan River at Lake St. John.

" No economic minerals in quantity were found on this route, but on Lake Commissaires veins of pink pegmatite were seen carrying detached masses of hematite up to three inches in diameter, but generally smaller ; some of these veins also hold large crystals of black mica, but these are considerably crumpled. A small detached area of anorthosite was found on the Ouiatchouan River similar to the great mass of that rock east of Lake St. John.

" Following this a close examination of all the rock cuttings along the Quebec and Lake St. John railway was made from Black River to the northern terminus. These cuttings afford admirable sections of the Archæan rocks in the area north of the St. Lawrence, which will be of great value in correlating the similar rocks found elsewhere in that region.

" A gray hornblendic granitite gneiss is found in the cuttings from Rivière à Pierre to Meguick. It is being quarried near the latter place for building stone. It is very valuable for heavy foundations and for exposed walls. About Lake Ouaquagamasis a red variety of the same rock would answer for building material quite as well as the gray, and would also likely prove valuable as a material for all purposes in which polished or worked granite in large blocks is required.

" Besides these building stones, the only other mineral of economic value observed was a small vein of mixed iron and copper pyrites, seen in the first cut south of Stadacona station ; this vein in itself is insignificant, but indicates the possibility of finding these minerals in veins of larger dimensions.

" On the completion of this examination a trip was made up the Montmorency River to beyond the beaver meadows, and the country explored eastward from there to the Sault à la Puce River, in order to trace out the northern boundary of the mass of anorthosite which occurs behind Chateau Richer, and which holds lenticular masses of titaniferous iron ore scattered through it.*

" Two weeks were then spent in Charlevoix county, where, in conjunction with Prof. Laflamme, the outliers of Trenton limestone along the coast were traced out, as well as the southern boundary of the large anorthosite area are seen on either side of the Goufre River, near St. Urbain. This area is particularly rich in titaniferous iron ore, which often occurs in immense masses. One of these is on the hillside

* Geology of Canada 1863, pp. 34, 46 and 589.

west of St. Urbain,† where thousands of tons of ore are in sight. This deposit was worked some years ago, but owing to the high percentage of titanic oxide present and the high cost of fuel profitable reduction was impossible and an extensive plant was abandoned.

"In the valley of the Goufre River a bed of peat, eighteen inches thick, was found, apparently overlaid by marine clays; this peat would form excellent fuel.

"In a coarse garnetiferous gneiss on the land of Edward Martin, St. Jérôme road, two veins of pegmatite hold considerable quantities of graphite in disseminated scales.

"At the conclusion of the work in Charlevoix county the party returned to Lake St. John, where Mr. Smaill, B. Ap. Sc., had been engaged carefully tracing out the junction between the Archæan and Cambro-Silurian rocks on the west and south sides of the lake. The indications of petroleum at Point aux Trembles were investigated; the Utica shales were there found to be highly impregnated with oil, but as the shale and limestone appear to form a synclinal basin in the Archæan valley, with only a few low, narrow anticlinal ridges, the possibility of a large collecting area for oil under the shales is doubtful.

"The Cambro-Silurian rocks of Lake St. John are also, as in the west, the source of mineral springs. Several of them occur around the margin of the lake, one comes out on the shore between Chambord and the mouth of the Matabetchouan River. The water of this spring is at present under analysis here, and it may prove of medicinal value.

"During September an exploration was made in the country north of Lake St. John on the Wassiemeska, Rat and Ours rivers, branches of the Mistassini River. On the first named only Archæan gneisses were seen to the limit of the explorations some forty miles north from the lake; but here numerous boulders of jasper conglomerate, felsite and diorite, closely resembling the rocks of the Huronian north of Lake Huron, were found, indicating that a Huronian area will be found farther to the northward.

"At the sixth and seventh portages of the Mistassini River a large band of crystalline limestone was noted. This band is irregular in thickness, and appears to thin out at the upper portage; an extension of the same or a similar band is exposed for several miles along the course of Rat River, from which it crosses into the Rivière aux Ours, where it is seen below the first fall, but is there only five feet wide, and apparently near its eastern limit. This limestone or marble is occasionally found free from impurities, but having a coarse granular texture is unfit for building or ornamental purposes. The greater

† Geology of Canada 1863, p. 35.

part of the mass holds a varying quantity of light brown mica in small scales, while veins and detached masses of white orthoclase and pink and green scapolite are also common. In some of the bands rounded grains of green hornblende or pyroxene are found, chiefly near the junction with the enclosing gneiss.

"The Rat River was followed thirty-two miles along its course, the upper five being through an anorthositic area, probably an extension of the large area seen on the Peribonka River."

The Rivière aux Ours was ascended only ten miles, as the river there becomes unnavigable for a considerable distance. The rocks seen on this stream were orthoclase gneisses, with the exception of the limestone noted above.

"On the completion of this trip the party disbanded and Mr. Low returned to Ottawa, on the 27th of September. Cost of the explorations, \$1,208.

Mr. Chalmers left Ottawa on the 5th of June to continue the survey and mapping of the surface geology of New Brunswick, his field work being the area included in the quarter-sheet map No. 2, S.E. This sheet embraces the county of Kent with adjacent portions of the counties of Westmoreland and Northumberland. His assistants were Mr. John H. McDonald, of Brockville, Ont., from the date of his leaving Ottawa till the 4th of October, and Mr. W. J. Wilson, of St. John, N.B., from the 30th June till the 15th of August.

The following is Mr. Chalmers's report on the season's work :—

"In the district to which this report relates the surface features are, generally speaking, uninteresting and monotonous, presenting the aspect of a low, level plain, which, however, rises gently towards the north-west margin. Between river valleys this flat Middle Carboniferous area is comparatively undrained, and hence much wet, barren land exists upon it, and shallow peat bogs are common.

"Making Weldford station our headquarters in the first part of the season we examined the country along the Intercolonial railway to the north and south. Numerous cuttings exposed good sections of the superficial deposits, and the rock surfaces exhibited striae in many places. Two well-defined sets of these were observed. The first set occurs along the railway to the north of Richibucto River, the striae trending about due east, and this course was found also near the coast in the Buctouche and Cocagne districts, varying in some places to points between east and north-east. The second set was seen along the Intercolonial railway to the south of Richibucto River, the striae

having a nearly north to south course. Good examples of the latter were discovered just south of Welford station where the rock surfaces were exposed during the construction of the railway exhibiting finely preserved striae with a course of S. 5° W. This is upon the water-shed between the Richibucto, which flows easterly into the Straits of Northumberland, and the Salmon River, flowing southwesterly into the St. John, or rather into Grand Lake, the elevation of this water-shed not being more than 200 to 250 feet above the sea. These two sets have only been produced by two different bodies of ice, both of which, to all appearances, have been local, the east and west striae by ice which moved towards the straits mentioned, and the north and south by ice which flowed either northwardly into the valley of the Richibucto, or southwardly towards that of the St. John River.

"Boulder clay is sparingly found in many places on the higher grounds, but the chief covering of the rocks is a coat of their own debris, in the form of gravels, sands, &c., intermixed with boulders, chiefly local, with which, however, transported ones occur in greater or less numbers. The local debris referred to is usually masked by stratified materials, the relations of the two being seen in river banks, especially below the 200 feet contour line. The whole superficial covering of the Carboniferous rocks, indeed, appears more or less stratified in the upper part, and is, generally speaking, deeper than that resting upon the other geological systems or formations of the province. It conceals the rocks from view everywhere, except along river valleys. The millstone-grit, in its decay, seems, however, to have crumbled down largely into arenaceous materials. Sandy loam is met with along river courses, and clay beds constitute the basal member of the stratified series in certain places, but are not common; hence the conditions necessary for the preservation of the shells of marine animals in the post-Tertiary deposits of this district are rare, and consequently very few of these are found in the fossil state.

"A noteworthy feature of the surface beds upon the area referred to is the presence of boulders of granite, felsite, diorite, etc., scattered broadcast over them and often embedded therein. The boulders are obviously derived from the Cambro-Silurian, Cambrian and pre-Cambrian rocks to the north-west. Near the coast and below the 200 feet contour line, however, they are sparingly intermingled, in some localities, at least, with others which are not so easily accounted for, and which appear to have been borne thither by floating ice. The direction in which the boulders on the higher parts of the district have been transported is exemplified by their greater or less abundance in the different localities as we recede from the parent beds. For example,

along the south-west Miramichi those of granite and other crystalline rocks are unusually large and abundant, and in many cases angular, being near the parent rocks; but as we proceed eastwards across the Carboniferous basin they become smaller and more scattered. These transported boulders are, however, merely the residual specimens of the vast numbers which have been borne thither. Remains of others which have crumbled to pieces are seen in the coarser gravels and sands in numerous places.

"The other superficial deposits of the district presented no new features worthy of consideration.

"The evidence regarding the Pleistocene subsidence indicates that it may have been slightly less here than in the Bay of Fundy and the Baie des Chaleurs basins. An old shore line, quite distinct, was observed at Galloway, near Kingston, at a height of 150 to 160 feet above sea level. A similar ancient shore line, at about the same elevation, occurs in the Miramichi valley.

"After Mr. Wilson joined our party on the 30th of June, he and Mr. McDonald examined the southern part of the district, following all the roads and streams. While they were thus engaged, I first visited the ship railway now under construction across the Isthmus of Chignecto, for the purpose of re-examining the formations disclosed in an excavation for docks which is now being made at its western end. This excavation is opened in the margin of the Amherst salt marsh, between the mouths of the La Planche and Missaguash rivers. The section exhibits in descending order—(1) marsh mud, (2) blue clay holding shells of *Mya arenaria*, *Macoma grænlandica*, and the young of *Buccinum undatum*?, (3) peat or humus, (4) red clay, and (5) boulder-clay, with local boulders. The bottom of the boulder-clay is not reached, although the excavation is upwards of 60 feet in depth. Afterwards I proceeded to Grand Manan, to examine one or two doubtful points there. Striation by ice, apparently from the mainland, and a few boulders evidently belonging to rocks other than those on the island, were observed on the higher parts, 350 to 400 feet above the sea. Returning to Kent county, I then made a canoe trip along the coast and around the lagoons inside of the sand dunes, which here form barriers along the shallow shores. Many interesting facts were noted regarding the formation of the sand beaches, lagoons, peat beds, salt marshes, etc.

"On the 3rd of October I visited St. John, with the view of re-examining the boulder-clay beds at Negrotown Point and the Fern Ledges. In company with Mr. Wilson, I measured a section of them at the latter place, to enable me to make a diagram exhibiting a deposit

of stratified clay intercalated therein. From St. John I went to St. Andrews to make some further observations on the glaciation of that section, more especially of Chamcook Mountain, etc. It was found that ice had ground completely over that hill, and that the summit, 637 feet above sea level, was scored and polished in a remarkable manner.

"Regarding the soil of the district examined during the past season, it may be remarked that it is, on the whole, good, especially along the coast and river banks, and also on some of the higher grounds between the streams. But large tracts are swampy, or covered with boggy material, constituting the so-called barrens. Wherever the natural drainage is sufficient to carry off the surplus waters due to precipitation, the land is fit for cultivation. It is, however, deficient in lime, and requires frequent applications of that material to bring it up to its highest yielding capacity. Good farming districts are found along the Richibucto valley, more especially on Nicholas River and Coal Branch, also in the Kouchibouguacis valley, and in the Buctouche and Cocagne districts.

"The forests of this part of the province, formerly so dense, and consisting of a mixed growth of trees, such as pine, spruce, birch, hemlock, cedar, poplar, hacmatac, etc., are now becoming greatly depleted. Large areas have been overrun by fires, and present little else but bare trunks and a scanty second growth. The destruction of timber from this cause alone is enormous. During the summer of 1888 the fires which swept over a large portion of the area under review destroyed valuable tracts of the forest.

"The materials of economic value met with in the district are few and unimportant.

"Peat is found in extensive bogs along the coast, especially near the Kouchibouguac, the Kouchibouguacis, Aldouane, Richibucto, and in many other places. These bogs are often deep, and produce abundant crops of cranberries. In the interior, large bogs often occur upon the flat, undrained portions of the district, but they are usually shallow, and in many cases support a scrubby growth of hacmatac and black spruce. No use has yet been made of peat in this part of the country.

"Gravel and sand, suitable for ballasting, road-making, etc., were observed in nearly every locality, and clay, available for brick-making, occurs in many of the river valleys. Fine blown-sands are abundant everywhere along the coast, forming the dunes or barriers already referred to.

"In the latter part of the season I visited the deposit of so-called magnetite, near the head of Millstream, Gloucester county, specimens

of which, analysed by Prof. Donald, chemist and assayer, Montreal, are reported to have yielded upwards of 60 per cent. of metallic iron, with 10 per cent of silica, etc. Considerable portions of the ore appear to be highly pyritous. About two miles distant from this deposit there occurs a vein of pyrites and galena, the former containing traces of gold and the latter of silver, according to an assay made by Mr. Hoffmann, chemist and mineralogist to the Geological Survey Department.

"Field work closed on the 4th of November and on the 6th I reached Ottawa. Mr. W. J. Wilson rendered me good service, and has now acquired such a knowledge of surface geology as to make him an efficient and valuable coadjutor in the work."

Cost of season's explorations, \$1,005.41.

Early in July, Professor Bailey was occupied in completing the work taken in previous seasons in the counties of Rimouski and Temiscouata, in the province of Quebec, and in obtaining the additional data required to complete the sections of the map illustrating this region. Respecting the work, he reports as follows:—

"Careful examinations were made of the rocks exposed along the lines of the Intercolonial and Temiscouata railways, with reference both to the succession of strata and the possible occurrence of fossils, while similar observations were extended to portions of the intervening district, between Little Métis and Rivière du Loup. The general result was to show that the greater part, if not the whole, of this district is occupied by the Sillery formation, supposed to represent an upper portion of the Cambrian system. A detailed report, with accompanying maps, is being prepared, and will be published during the year.

"About the 25th of July I proceeded, in accordance with your instructions, to the province of Nova Scotia, and entered upon the study of the geology of Queen's and Shelburne counties. Having been desired by you to give my first attention to the coast, operations upon the latter were begun at the town of Liverpool, and were continuously carried on until the entire coast, from Port Medway harbour, forming the eastern boundary of Queen's county, to Pubnico harbour, forming the western limit of Shelburne, had been examined. This work was found to be unexpectedly easy, owing to the circumstance that almost the entire shore is occupied by fishermen, and bordered by roads which give easy access to any desired point. The comparative uniformity of the rock formations, consisting chiefly of fine grained gneisses, quartzites and mica schists, together with irregular masses of granite, further facilitated their study. The general result of these observations was

to show the crystalline rocks in question, which occupy a belt along the coast of from two to fifteen miles in width, are only a more highly altered condition of the gold-bearing slates and sandstones of the interior.

"Having completed the study of the coast, attention was next given to the more accessible portions of the inland districts. Every road in the two counties was traversed and observations were made on the character and relations of their rock formation, particular attention being paid to the country embracing the gold districts of Molega Lake and Whiteburne. The several members of the gold-bearing series were clearly distinguished, and numerous facts ascertained bearing upon their succession and the plications by which they have been affected, facts of the first importance in connection with the development of the gold industries of the district. A report embodying the results of these observations is now in course of preparation, but cannot well be completed until examinations are made of the numerous lakes and streams by which the country is intersected, and for the traversing of which there was not sufficient time during the past season. One of the streams, the Port Medway, affords admirable opportunities for this purpose, forming an almost continuous rock section from the border of Annapolis county to the coast, and its careful study will supply a key to the structure of the entire region."

Mr. Fletcher left Ottawa for Nova Scotia on the 8th of July, 1890, and continued fieldwork until the second week in December, being engaged during the greater part of that time in an examination of the district lying west of that surveyed in 1889, including a portion of the counties of Colchester and Hants.

His assistants were M. H. McLeod for six months, B. A. L. Huntsman for two months and a half, and D. I. V. Eaton, who is still employed. The cost of the season's explorations, including salaries of assistants, will be \$1,300.

Within the area examined, Triassic, Carboniferous limestone and Devonian rocks are well exposed.

Between the Intercolonial railway along the Salmon River and the valley of the Stewiacke River, the country is occupied chiefly by the rocks of Union and Riversdale, described in previous reports as Devonian. These, at Brookfield, are referred by Sir Wm. Dawson to the Devonian, but south of Truro, to the lowest part of the Carboniferous. Dr. Ells, who considers them Devonian, traced them in 1884 nearly to the Shubenacadie River where they are succeeded by Carboniferous limestone; but beyond this river quartzites and

slates also occupy a considerable portion of the shore of Minas Basin at Walton, Split Rock, Somerville Landing and Avonport, and are seen in most of the brooks from Maitland as far as the mouth of the Gaspereaux River. Although at a few points west of Clifton the Carboniferous limestone comes between them, they are as a rule capped on the north by Triassic strata. These occupy, in nearly horizontal attitude, a basin which extends westward from near Valley Station, one rim fringing the south side of Minas Basin, the other reaching much further inland on the north side.

South of the Devonian slates, Carboniferous limestone occupies the basin of the Stewiacke River from Eastville to its confluence with the Shubenacadie, whence it stretches from Brookfield to Gay's River; thence up Shubenacadie River to Enfield, where it rests on Cambrian rocks of the Atlantic coast gold-bearing series and down stream to Maitland and Blackrock. Outliers are also found on Minas Basin, and a broad belt lies, as already stated, along the Kennetcook River.

Between the gold-bearing rocks and the Carboniferous of Stewiacke lies a great mass of drift sand, gravel and boulders.

Good sections across the country are given by the road from Walton to Brooklyn and Newport station, by that from Noel through Kennetcook Corner to the Gore, and from the Gore to Shubenacadie station. The first crosses principally Carboniferous limestone to the contact of the gold-bearing rocks, a short distance east of Newport station. The second shows first Devonian, then Carboniferous limestone, with the small coal seams of Kennetcook, then the great band of soft micaceous and chloritic slates of various colours, which enclose the cross-leads of quartz, from which are derived the stibnite of the West Gore antimony mine and the gold of Central Rawdon. From the last named locality come the forms found at the gold mines last summer by Professor Hind, supposed by him to be *stromatopora*, but which, on examination by Mr. T. C. Weston, of the Geological Survey, proved to be only concretions of dolomite. From Shubenacadie and Elmsdale to the slates of the Gore—once quarried for roofing slate—the rocks are chiefly Carboniferous limestone.

A careful survey of the Devonian rocks and Carboniferous limestone of the East Mountain of Onslow and Penny's Mountain, in Clifford's and Farnham's brooks, has shown that the latter rest, in small patches, on the former, with the most complete and satisfactory evidence of unconformity, and unconformity scarcely less evident is seen also at Walton and Cheverie.

The Trias seems to yield no minerals of economic value, its sandstones being too crumbly for building, and its concretionary beds too impure for limestone. In the Lower Carboniferous, on the other hand, limestone quarries abound, some of which at Brookfield, Stewiacke, Shubenacadie and elsewhere, are extensively worked. The red hematite of Newton Mills is a deposit at the junction of the Carboniferous limestone, and conglomerate with the Cambrian gold-bearing series, and similar ores may be expected at other points along the line of contact. The limonite of the Brookfield iron mine is also at or near the base of the Carboniferous. It is now being vigorously worked by the New Glasgow Coal, Iron and Railway Company, who are also working their East River of Pictou iron areas, near which they are erecting a large blast furnace (see "Canadian Mining Review" for August, page 113.) At the same horizon, probably, are the manganese mines of Tenny Cape, Walton, Cheverie and East Onslow. That of Tenny Cape has continued for many years to supply a large quantity of the purest manganese di-oxide (pyrolusite).

From quarries near Windsor, Cheverie and Walton large quantities of gypsum are exported to the United States, and plaster is also worked on a smaller scale at Beaver Brook, Shubenacadie, Stewiacke and other places within the area.

In the East Brook, which flows into Stewiacke River from the south, about eight miles above the station, a seam of coal, apparently not exceeding eighteen inches in thickness, of mixed coal and carbonaceous shale, was lately opened. A boring sunk about 80 feet at Johnston Brook, not far distant, is said to have cut black gypsum, and the coal is probably about the same horizon as that of Kennetcook. The celebrated scythestone of Birch Hill, a fine gray sandstone, with sharp grains of silica, is found in the same neighbourhood. Coal was also reported to occur at Selma, but the report seems to have arisen from the presence of thin bands of dark gray shale, marked with fossil plants, among thick beds of gray flinty sandstone, which forms barrens in the neighbourhood. At the request of Mr. Robert H. Fraser, Superintendent of the Nova Scotia Central railway, a visit was paid on the 20th of October to borings made in search of coal at Spa Springs, Annapolis County. One hole had been sunk 100 feet, but nowhere in the neighbourhood were rocks seen in which coal could reasonably be expected to occur. Beneath what appears to be an overflow of coarse dolerite near the top of a steep slope lies a layer of bright greenish clay rock, underlaid by dark graphitic argillite, from a few inches to several feet thick, succeeded below by bright red rocks, presumably of Triassic age.

Great excitement was caused last summer by the reported discovery of gold in a whitish-gray flinty conglomerate consisting almost wholly of pebbles and grains of white quartz, beds of which underlie the Carboniferous limestone from the neighbourhood of Brookfield, far up the Stewiacke River on the north side. The region was proclaimed a gold district, and rights of search taken out covering many miles. The attention of prospectors was, moreover, directed to all the conglomerates in the province. That the conglomerate on Gay's River is auriferous has long been well known, and Professor Hind has proved the existence of gold, silver and copper in certain beds of that nature near Baddeck. The Brookfield conglomerate was said to have given rich returns by milling, although a somewhat close examination by panning the dirt in the beds of the streams flowing over it failed to indicate the presence of gold in appreciable quantity. Two samples were sent to Mr. Hoffmann, one from the neighbourhood of the barytes mine, the other from the brook three hundred yards above the Glenbevie mills; but neither of them yielded, on assay, a trace of either silver or gold. Tests subsequently made on a large scale at the mill of one of the gold mines emphatically confirmed the accuracy of Mr. Hoffmann's assays.

It has been shown that the rocks of the Londonderry iron mines, formerly supposed to be Devonian, and subsequently Silurian or Cambro-Silurian, everywhere contain Devonian plants; and as similar slates were stated by Mr. Scott Barlow to be largely developed in the west branch of Economy River, it was deemed advisable to re-examine these latter for comparison, and to collect specimens of the fossils with which they are crowded. In 1876, from dark shales in situ in a little brook at Farmington, in Cumberland county, a locality of slaty rocks to which also attention was directed by Mr. Barlow, and at which he obtained trilobites in 1876, several species of graptolites and other Silurian fossils were collected. In Bulmer Brook and other brooks of this vicinity, pre-Carboniferous argillites were seen in contact with traps, agglomerates, felsites and other rocks of similar origin.

The conclusion arrived at, that large areas hitherto mapped as Cambro-Silurian are no older than Devonian, led to a short re-examination of the Cambro-Silurian strata of the iron mines of the East River of Pictou. These, however, appear to be older than the rocks of Londonderry.

Mr. E. R. Faribault left Ottawa on the 11th of June, with instructions to continue the detailed surveys of previous years and study the

stratigraphical structure of the gold-bearing series of rocks of the Atlantic coast of Nova Scotia.

The district surveyed lies westward of that surveyed in 1888, and southward of that surveyed in 1889, extending along the sea shore in Halifax county from Tangier to Lawrencetown and some twenty miles inland, an area of about 375 square miles.

The auriferous Lower Cambrian rocks of the country are cut by an uninterrupted belt of granite, two to four miles wide, extending westward to within two miles of Waverly. The folds of the gold-bearing series, and more especially the anticlinal axes, were carefully examined and traced out, on account of their close relation to the richest auriferous belts.

The gold mining districts of Tangier, Lake Catcha and Head of Chezzetcook are situated in the region examined. These districts were carefully studied as to their geological structure, and found to be on the axes of anticlinals, and are the auriferous leads of Murphy's Cove and Black Point of Ship harbour, Clam Bay and English Point of Jeddore, and those on the south side of Conrod and Thomson lakes are similarly situated.

Three miles up the Musquodoboit road a few tons of loose argeniferous galena ore were taken out, along four levels tunnelled in granite debris on the face of a hill. An assay of the ore is said to have given a good showing of silver, but so far the developments made have not reached the bed rock.

Some fossil forms, taken from the gold-bearing slates at the Northup gold mines at Rawdon, and believed to be of organic origin, were found on microscopic examination by Mr. T. C. Weston to be merely concretions.

Mr. Ed. Gilpin, Inspector of Mines in Nova Scotia, has found markings on Lower Cambrian rocks near Bedford which may prove of some importance in determining more definitely the age of this series.

Mr. Faribault was assisted, as in previous years, by Messrs. A. Cameron, J. McG. Cruickshanks and P. A. Faribault.

The season's work extended until the first of November; cost \$1,106.54.

MINERAL STATISTICS AND MINES.

Mr. E. D. Ingall, Mining Engineer in charge of the division of Statistics and Mines, makes the following report on the work done during the past year :—

"The early part of the year was occupied with the ordinary routine connected with preparation of statistics of mineral production, etc., during 1889. A summary of this was printed and distributed in April, and the full report was issued in November. Considerable attention has also been given to devising more complete and efficient methods for attaining the objects sought in establishing the Mining division of the Department. To this end, efforts have been made to revise and complete the Directory of producers of economic minerals and of the localities where the various minerals are worked, or occur in the Dominion : these latter are being geographically represented on maps by means of a complete system of conventional signs. In the compilation of this schedule of signs those already in use by the Survey have been taken as a basis, others invented, where necessary for the completion of the list, and the whole elaborated so as to show not only the metallic ore dealt with, but also the particular ore yielded by the deposit.

"Preliminary steps have also been taken towards the more systematic arrangement of the mining records, such as of borings, mining plans, reports, etc., and the cataloguing of the same, while effort has also been directed towards the more continuous and regular acquirement by the office of general mining information at frequent regular intervals during the year from the several mining districts.

"During the summer investigations were made by myself and by Mr. Brumell, regarding the progress and condition of the mineral industries in a number of mining districts in Ontario, Quebec and New Brunswick.

"As last summer was the first opportunity I have had to visit most of the mining districts referred to, the investigations made were more or less of a preliminary and general character, and were undertaken to familiarize myself with the aspect and leading features of the several districts, and to become better acquainted with the mine owners and managers, and thus be able to deal more intelligently with the returns and the reports sent by them to the Department.

"With this object in view the iron, mica and phosphate districts of the eastern part of the province of Ontario were visited, as also were the Madoc gold and iron centres, likewise the Sault Ste. Marie and the Sudbury mining districts. Attention was also directed to the salt, gypsum, petroleum and natural gas industries, the two latter receiving special attention from Mr. Brumell.

"In Quebec visits were made to the gold, asbestos and copper mining, and slate quarrying districts of the Eastern Townships, as well as the newly started asbestos mines and phosphate mines of Ottawa

county. In New Brunswick the coal and manganese mines were visited, and also the gypsum and granite quarries, etc.

"During the summer Mr. Brumell visited several points in Ontario where boring operations were being carried on. Notes on these were made and information relating to old borings and the occurrence of gas and oil was obtained. Mr. Brumell states:—

"In Essex county extensive drilling operations were in progress at various points, more especially in the district between Essex Centre, Harrow and Leamington. At Essex Centre the Central Gas and Oil Company of that place have finished a well 1,200 feet in depth without, however, any economic result, as neither gas nor oil were obtained. At Walker's Marsh, the Messrs. Walker and Sons, of Windsor, have finished three wells from which a very considerable flow of oil was obtained. They have also been actively carrying on operations in other parts of the county and in the adjoining county of Kent. The Citizens Gas, Oil and Piping Company, of Kingsville, during the year drilled on the road allowance, west of the well known as 'Coste No. 1,' where a daily flow of gas amounting to over 7,000,000 cubic feet per day was obtained; this gas is now being utilized in lighting the streets of Kingsville, to which town it has been piped. The drilling of this well was the cause of considerable litigation between the owners and the Ontario Natural Gas and Fuel Company, the owners of 'Coste No. 1,' the result of the suit was, however, in favour of the former company the injunction given at the instance of the latter company not being sustained. The Ontario Natural Gas and Fuel Company have, it is understood, again undertaken operations in the county, in that part between 'The Marsh' and Essex Centre, with what result, however, we are unacquainted. Various other operators have been working throughout the country, but owing to lack of time I was not enabled to ascertain the result nor the extent of their operations.

"In Kent county, in addition to the work done by Messrs. Walker & Sons, mentioned above, a certain amount of work has been carried on, notably the well sunk by the Citizen's Gas Company of Blenheim, where in a boring 900 feet deep small flows of gas were obtained at 700 and 800 feet.

"At Stratford, Perth county, a boring was undertaken by the Stratford Natural Gas Company, which at the time of my visit, on the 12th of August, had reached 900 feet without encountering gas or oil.

"In Welland county the Provincial Natural Gas and Fuel Company, have finished their series of wells to the number of fourteen, all of which are situated in the townships of Bertie and Humberstone, in the vicinity of Sherks Station on the Grand Trunk railway. Other

operators have been busy throughout the county, notably Messrs. Conmiller & White, who drilled for and obtained gas in the town of Port Colborne. John Rube struck gas a few miles west of that town, this gas is being utilized in the firing of lime-kilns owned and operated by Mr. Rube. Another lime producer, Mr. Carroll, drilled in the south-west part of Bertie township, and in the northern part of Port Colborne, Mr. Edward Wear struck a well from which a daily flow of gas of over 400,000 cubic feet is recorded.

"In Wentworth county considerable activity has been evinced in the search for gas and oil, several wells having been sunk in the vicinity of Hamilton, though with what result was not ascertained.

"Outside of the counties above mentioned, but little has been done except in the county of Lambton, where, in the oil territory of Enniskillen township, the usual amount of boring has been carried on and many new wells brought in with the usual average daily flow of oil."

A detailed report of the gas oil and salt wells in Ontario is now being prepared by Mr. Brumell.

In reference to the development of the gas and oil industry of which particulars are given above as regards Ontario, I desire to again call attention to a district in the province of Quebec, viz.: The valley of Richelieu River, north of St. Hyacinthe, on the Grand Trunk railway, as one in which there are strong probabilities of remunerative gas or oil wells being struck at depths probably not exceeding 1,500 or 2,000 feet. The whole area is underlaid by the Trenton limestone and already, further north-east, near Lake St. Peter, a considerable flow of gas was struck, but which, so far, as I can learn, has never been utilized in any way. This well was described in the Summary Report for 1887. That the discovery at St. Grégoire should not have been more energetically followed up, is probably accounted for, if, as I am informed, one company has acquired by charter an exclusive right to seek and use natural gas in and over the whole province of Quebec.

"Mr. Jas. White's time was occupied in completing surveys of the south-west corner of the map illustrating the River du Lièvre, and Templeton phosphate districts, and in making surveys of mines and workings in the Eastern Ontario phosphate, mica and iron districts, comprising the workings and pits of some 22 mines.

"Since returning from the field in the fall, the time has been occupied in the ordinary routine work of the division; collecting and preparing the material for the annual report; answering inquiries, etc., together with a continuation of the work of preparation of the Directory, and maps of mineral occurrences, etc. It is hoped, that some of these maps will be published during the coming year.

"The number of circulars sent out, together with the reminders found necessary, amounts to about 5,500, besides about 650 letters sent, and some 500 received."

CHEMISTRY AND MINERALOGY.

With reference to the work carried out in this connection, Mr. Hoffmann reports as follows:—

Agreeably with the practice of former years, the work carried out in the chemical laboratory has been of an almost purely practical character; but few examinations or analyses having been made other than material which it was deemed might, not improbably prove of some importance. The work embraced:

- I. Analyses of fuels.
- II. Analyses of limestone and dolomites.
- III. Analyses of mineral waters and brines.
- IV. Analyses of iron ores.
- V. Gold and silver assays.
- VI. Miscellaneous examinations—under which heading are included clays, marls, saline deposits, etc., etc.

The number of mineral specimens received, brought or sent, for examination amounted to five hundred and fifty-eight. The greater number of these were brought by visitors, to whom the required information in regard to their economic value was communicated at the time of their visit. In other instances, those where a more detailed examination appeared called for, or when the specimens had been sent from a distance, the results were sent by letter. The number of letters written, the majority of which were of the nature of reports, amounted to two hundred and forty-six. The number of letters received, one hundred and forty-eight.

Mr. F. G. Wait has, as a principal work, been engaged in the analyses of some twelve samples of brine from Lake Winnipegosis, collected by Mr. J. B. Tyrrell; the inquiry having for its object the ascertaining if these brines would be suitable for the manufacture of salt.

Mr. R. A. A. Johnston has, in addition to a great variety of miscellaneous work, conducted a series of analyses of limestones and dolomites, with the view of ascertaining their relative merits, in so far as chemical composition is concerned, for structural and other purposes. He has also examined numerous samples of ore in regard to their nickel content.

In the work in connection with the mineralogical section of the Museum, I have been most ably and faithfully assisted by Mr. R. L. Broadbent. In addition to the work of labelling, readjusting specimens and maintaining the collection generally in an orderly condition, he has completed the rough draft of a catalogue of the economic collection of minerals, so that the manuscript of the whole catalogue for this section of the Museum will now very shortly be ready to place in the hands of the printer.

A great many of the mineral specimens have been replaced by more characteristic ones, and the collection augmented by the addition of some three hundred others. Of these the following were collected by members of the staff :—

1. Dr. G. M. Dawson :—

Ninety specimens of gold and silver ores from British Columbia.

2. Mr. A. E. Barlow :—

Thirty specimens of copper and nickel ore from Sudbury and vicinity.

And the undermentioned constituted presentations :—

1. Allan, W. A., Ottawa, O. :—

Magnetite, from lot 1, range I., of the township of Torbolton, in Carleton county, O.

2. Baker, Lieut-Colonel James, M.P.P., Cranbrook, Kootanie, B.C. :—

A sample of crude petroleum, from Sage Creek, Flathead River, East Kootanie, B.C.

3. Byrne, W. E. :—

Galena, from mine on Mill Stream, township of Beresford, Gloucester county, N.B.

4. Campbell, A. M., Perth, O., per A. E. Barlow :—

Martite, from the Dalhousie mine, Dalhousie township, Lancaster county, O.

5. Canadian Copper Company, Sudbury, O., per Wm. Evans, Manager :

(a.) Pyrrhotite (nickeliferous), and

(b.) Chalcopyrite and pyrrhotite (nickeliferous), from the Copper Cliff mine, lot 12, range II. of the township of McKim, district of Nipissing, O.

(c.) Sample of foregoing ore, after roasting.

(d.) Sample of matte containing 17 per cent nickel and 23 per cent copper.

- (e.) Nickeliferous pyrrhotite and chalcopyrite, from Evans's mine,
lot 1, range I. of the township of Snider, district of
Algoma, O.
6. Dickson, Wm., Pakenham, O. :—
Silicified wood, from Long Lake, N.W.T.
7. Donald, J. T., Montreal, Q. :—
Scolecite, from Black Lake, township of Coleraine, Megantic
county, Q.
8. Ferguson, J., Newcastle, N.B. :—
Iron ochre, from the North-west branch of the Miramichi, North-
umberland county, N.B.
9. Gordon, W. H. Lockart, Toronto, O. :—
(a.) Apatite, from lots 13, 14, 15 and 17, range XI. of the town-
ship of Monmouth, Peterborough county, O.
(b.) Apatite, from lot 4, range III. of the township of Dudley,
Peterborough county, O.
(c.) Apatite, from lot 11, range V. of the township of Dysart,
Peterborough county, O.
(d.) Apatite, from lot 21, range XI. of the township of Harcourt,
Peterborough county, O.
10. Grace, P., Gracefield, Q. :—
Mica, from lot 38, range I. of the township of Bouchette, Ottawa
county, Q.
11. James, Joseph, Bridgewater, O. :—
(a.) Asbestus, from lot 7, range XI. of the township of Elzevir,
Hastings county, O.
(b.) A sample of the ground asbestos.
(c.) Roofing cement prepared from the same.
12. McKinsey, Hon. G. C., Milton, O. :—
Seven specimens of terra-cotta ware.
13. Matthis, Bro., Ottawa, O. :—
Clay nodules, from Green's Creek, Gloucester township, Carleton
county, O.
14. Murray, John, Spence's Bridge, B.C. :—
Gypsum, from vicinity of Spence's Bridge, B.C.
15. Northup, Gould, per Hugh Fletcher :—
Native gold in quartz, from the Central Rawdon gold mine,
Hants county, N.S.
16. Payne, W. R., Bathurst, N.B. :—
Magnetite, from head of Mill Stream, township of Beresford,
Gloucester county, N.B.

17. Poole, H. S., Stellarton, N.S. :—
Stalagmite, from the Acadia coal mine, Pictou county, N.S.
18. Robotham, Capt. J. G. C., Victoria, B.C. :—
Infusorial earth, from Quamichan, Vancouver Island, B.C.
19. Scott, J. G., Quebec, Q. :—
A six-inch cube of dressed limestone, River Mistassini, about thirty miles from Lake St. John, Q.
20. Soues, —, Clinton, B.C. :—
A nugget of native copper, from Eleven-Mile Creek, Fraser River, B.C.
21. Sperry, Francis L., Sudbury, O. :—
Sperrylite, from the Vermilion mine, lot 6, range IV. of the township of Denison, district of Algoma, O.
22. Willimott & Co., Ottawa, O. :—
(a.) A collection consisting of 119 specimens of Canadian cut-stones.
(b.) Strontianite, from Carleton county, O.

Mr. C. W. Willimott reports that during the early part of the year, he was engaged making up collections of minerals and rocks, for the following institutions :—

High School, Beamsville, Ont	113
do St. Johns, Que	113
Commercial Academy, Quebec, Que.—(Supplementary)	20
Mechanics Institute, Wingham, Que	121
High-School, Paris, Ont	113
Shefford Academy, Shefford, Que	113
Royal Military College, Kingston, Ont.—Supplementary	54
Collège St. Rémi, county of Napierville, Que	106
High School, Essex Centre, Ont	109
do Parkhill, Ont	109
Separate School, Freelton, Ont	109
Collège Set. Anne de la Pocatière, Que	109
St. Francis College, Richmond, Que	109
Presqu’Ile Park Museum, Presqu’Ile, Ont	109
High School, Guelph, Ont	115
Superior School, Petit Rocher, Gloucester county, N.B	13
Collegiate Institute, Hamilton, Ont	103
Total	1,648

A collection of 400 specimens of minerals and rocks was sent in for identification by the Collège St. Laurent, Montreal, these were named and returned. That during the summer, between the 11th of August and the 16th of September, several mineral localities in the townships of Hull and Wakefield were visited to obtain specimens, required for making up collections. Only those localities were examined, which it was thought would afford the best specimens. In some instances poor success was met with, either from the running out of the mineral, or from being unable to find the exact locality, owing to the dense growth of underbrush. Nevertheless ten boxes of suitable specimens were collected, including some fine examples of crystals. Considerable delay was caused by the extremely wet weather, making the search through the thick woods unpleasant and difficult.

Mr. W. F. Ferrier has been chiefly occupied in the study of collections of rocks brought from various parts of the Dominion by the field geologists and explorers of the staff.

A considerable portion of his time has also necessarily been devoted to superintending the preparation of thin sections of these and other rocks requiring identification, the arrangement of a large number of specimens collected by Dr. Lawson, Mr. Adams and others, and other routine work.

Good progress has also been made in the determination, naming and labelling of the rocks in the general stratigraphical collection exhibited in the Museum, which, when properly classified and arranged, will be invaluable as a reference collection. Numerous specimens have been handed to him from time to time, and identified by their microscopical characters and simple blowpipe tests.

A few of the building stones from British Columbia have been studied microscopically to determine their true character and durability, and further work is purposed in this direction.

The series of Archaean rocks collected by Mr. Tyrrell from Lake Winnipeg, and by Dr. Bell and Mr. Barlow from the Sudbury region, which show many striking points of resemblance are now being investigated. 121 of the specimens of rocks brought in by the field parties, have been studied in thin sections, with the microscope and reported on during the past six months.

PALÆONTOLOGY AND ZOOLOGY.

In addition to museum work and his other official duties, Mr. Whit eaves has been engaged, during the past year, in a critical study of the fossils of the Devonian rocks of the Mackenzie River district and of

Northern Manitoba. The manuscript of the third part of the 'Contributions to Canadian Palaeontology,' which consists of a report upon the collections of fossils made by Mr. McConnell in 1887-89, from the Devonian rocks of the Hay, Mackenzie and Peace rivers, was finished in September, and the four plates required for its illustration were printed. Before sending the MS. of this report to the printer, however, the receipt of an additional and important collection of fossils, made by Mr. McConnell during the summer season of 1890 from the Devonian rocks of the Athabasca River and its tributaries, induced the writer to enlarge its scope, so as to make it include not only all the raw material obtained by Mr. McConnell, but also three small collections of fossils made by Prof. Macoun, Mr. A. S. Cochrane and Dr. Bell, in 1876, 1881 and 1882, from the Devonian limestone of the Athabasca and the Clearwater. The report as thus enlarged has been rewritten, an additional plate has been prepared to illustrate it, and the whole is now ready for publication.

Considerable progress has been made in the study of the unusually extensive collections of fossils made by Mr. Tyrrell, in 1888-89, from the Devonian and Silurian rocks of lakes Manitoba and Winnipegosis. The generic and specific relations of nearly all the sponges, brachiopoda and cephalopoda, and those of most of the pelecypoda, gasteropoda, crustacea and fishes in these collections have been ascertained and a preliminary list of them prepared for publication in Mr. Tyrrell's forthcoming report on the geology of this region. Some of the more critical of the mollusca and most of the corals and polyzoa have, however, yet to be studied. At an early date it is intended to publish an illustrated report upon the whole of these fossils in the fourth and concluding part of the 'Contributions to Canadian Palaeontology.' In the meantime a paper descriptive of fifteen of the most striking species of brachiopoda and mollusca in these collections has been prepared and published in the 'Transactions of the Royal Society of Canada' for 1890. It consists of eighteen pages quarto and is illustrated by seven full page plates.

In August a fortnight was spent with Dr. Ells in an examination of the fossiliferous exposures near Philipsburgh, St. Dominique and Mystic, P.Q., and several species of fossils new to that district were obtained. In September a short visit was made to Hamilton, Hagersville and Cayuga, Ont. At the first named place a number of local collections were examined and several specimens of interest secured for the museum, especially a series of jaws, vertebrae and other bones, of snakes, small rodents and insectivora from the upper part of the sand and gravel ridge at Burlington Heights. From the Corniferous lime-

stone of the neighbourhood of Hagersville a small collection of fossils was made which includes specimens of a few species not previously represented in the Museum.

The MS. of the first part of a descriptive monograph of the Vertebrata of the Tertiary and Cretaceous rocks of the North-west Territory, by Prof. E. D. Cope, has been received during the year and is now in type. It contains a description of the species from the White River beds (Older Miocene) of the Swift Current Creek region of the Cypress Hills and will consist of twenty-seven pages quarto, illustrated by fourteen full page plates.

The MS. of the third part of the 'Contributions to Canadian Micro-Palaeontology,' by Prof. T. Rupert Jones, F.R.S., has also been received and is now in the printer's hands. It consists of a description of a number of Ostracoda from the Cambro-Silurian, Silurian and Devonian rocks of Canada, and will be illustrated with two full page large octavo plates.

In the Department of Zoology another large collection of the mammalia, birds, reptiles, etc., of British Columbia, has been received from Prof. Macoun. Fifteen specimens of mammals, ninety-five of birds and two of turtles have been skilfully mounted by Mr. Herring during the past year, and twenty-four bird skins have been put up by him. Among the most striking of the additions to this branch of the museum are a remarkably fine specimen of the Musk Ox (*Ovibos moschatus*), from Fort Rae, on Great Slave Lake, recently presented by Julian Camsell, Esq., Chief Factor of the Hudson Bay Company in the Mackenzie River district, and an adult male of the Woodland Caribou (*Rangifer Caribou*), from the Selkirk Ranges of British Columbia, obtained by Dr. G. M. Dawson.

For two months and seven days during the past summer the duties of Acting Director have been performed by Mr. Whiteaves, and in addition to the correspondence thereby occasioned, 220 official letters have been received during the year, and 220 written.

From the 6th of January to the 26th of June, Mr. T. C. Weston was confined to his house by severe illness. He subsequently obtained leave of absence until the first of August, and during that time and up to the 8th of September he was occupied in the examination of the rocks in the neighbourhood of Quebec city, from which he was successful in obtaining a remarkable and in some respects unique set of fossils, which throw considerable light on the age of these rocks, which is still under discussion. From the 10th of September until the close of the year, Mr. Weston's time has been spent in museum work, in the palaeontological and archaeological sections, in arranging several hundreds of

new specimens in the cases, in preparing descriptive labels for them, and the like.

Mr. L. M. Lambe was engaged in the early part of the year in the study of collections of fossils from Lake Winnipegosis and the Hay River, collected by Messrs. Tyrrell, Dowling and McConnell, in assisting in their determination and preparing drawings for their illustration.

During the latter part of July and in August Mr. Lambe, with Mr. Dowling, made a collection of fossils from the Cambro-Silurian rocks of Lake Winnipeg, from Dog Head on the south to the Little Saskatchewan on the north, and then east to Beren's or Swampy Island, including all the islands off that part of the western shore of the lake. He also visited East Selkirk, Manitoba, and made a collection of fossils at that place.

After his return, Mr. Lambe assisted Mr. Whiteaves in an examination and study of some Devonian fossils from Lake Winnipegosis, and prepared plates for their illustration in the transactions of the Royal Society of Canada for 1890, and has since been engaged in the study of some fossils collected by Mr. McConnell on the Athabasca River during the summer of 1890.

During the past year Mr. H. M. Ami's time has been occupied at intervals in sorting, identifying and labelling large collections of fossils which have not been unpacked since they left Montreal. About 20,000 specimens were examined with this end in view, and all of these are now accessible and available for reference or as duplicates. In March he made a selection of about 100 specimens of fossils and Indian remains belonging to the estate of the late Sheriff Dickson, for the Museum. He also assisted in a preliminary examination of fossils recently received from the North-west Territories, and spent some time in rearranging the palæontological part of the library, with a view to making a catalogue thereof. In April Mr. Ami identified and labelled some 250 fossils for the St. Laurent College, Montreal, and some other specimens for a private collector at Hamilton in return for donations to the Museum. He also prepared systematic lists of species from various localities in Ontario, Quebec, Nova Scotia and New Brunswick, and selected several especially among the graptolidæ, monticuliporidæ and ostracoda, which require further study. With Mr. Herdt's assistance and during Mr. Weston's illness, he attended to the reception, registration and arrangement of the archæological specimens brought in by officers of the Survey or presented by them. During the month of May he arranged, classified and labelled the vertebrate remains of the Lower Miocene of the Cypress Hills upon which Professor Cope has recently reported. A collection of fossils, consist-

ing of 61 species and 184 specimens, has been prepared by Mr. Ami and sent to the Museum of Queen's College, Kingston, in July, and another, consisting of 365 specimens, was sent to the Redpath Museum, Montreal, in October. Small sets of fossils have been loaned or sent, for scientific purposes, to various specialists, especially to Professor Hall at Albany, Mr. C. D. Walcott at Washington, Professor E. D. Cope at Philadelphia, and Dr. J. G. Hinde of Croydon, England. At the end of October he visited Quebec city and collected a series of fossils from the neighbourhood and named several hundred specimens of fossils for the Laval University. In November he prepared systematic lists of fossils for Mr. Low's report on the geology of the counties of Portneuf, Quebec, Montmorency and Champlain, P.Q., and identified a few fossils from the black shales of Mr. Wissick, Lake Temiscouata, for Professor Bailey. He has also made a preliminary examination of the collections of fossils from Quebec city, made by Mr. Weston during the past summer, and of those made by Dr. Ells, Mr. Giroux and Mr. Deeks in the Eastern Townships. He has also prepared labels for a number of species of Cambrian and Carboniferous fossils which were previously unlabelled. From the 3rd May to the 1st September he was assisted by Mr. H. D. Herdt, a science student of McGill University.

The following collections have been received during the year from members of the staff:—

Dr. G. M. Dawson :—

174 specimens of fossil plants, shells, etc., from the southern interior of British Columbia. Six specimens of the fresh-water pearl mussel (*Margaritana margaritifera*) from the headwaters of the Bonaparte River, B.C. One fine specimen of the Woodland Caribou (*Rangifer Caribou*). About 200 specimens of arrowheads, jade implements, etc., from British Columbia.

J. F. Whiteaves :—

Fifty specimens of fossils from the Corniferous of Hagersville, Ont.

Dr. R. W. Ells :—

About 1,200 specimens of fossils from the Cambrian, Cambro-Silurian and Silurian rocks at numerous localities in the province of Quebec. Hairy-tailed Mole (*Scapanus Brewerii*) from base of Orford Mountain, P.Q.

Hugh Fletcher :—

Fifty-four specimens of Silurian and other fossils from Economy River and River Philip, N.S. About sixty specimens of Carboniferous plants from the Pictou and Springhill coal mines of

Nova Scotia, through Messrs. H. S. Poole and William Madden.

R. G. McConnell :—

About 300 specimens of fossils from the Devonian and Cretaceous strata of the Athabasca River and its tributaries.

J. B. Tyrrell :—

500 fossils from the Assiniboine and Saskatchewan rivers and Lake Winnipeg region of Manitoba.

T. C. Weston :—

284 specimens of Cambro-Silurian fossils from the Montcalm market and Cove Field rocks of Quebec city, Que. One spear head from Hog's Back, Nepean, Ont.

H. M. Ami and H. D. Herdt :—

A number of fossils from the post-Tertiary deposits of Moose Creek, the post-Tertiary and Cambro-Silurian formations of the city of Quebec and vicinity of Ottawa. Eleven archaeological specimens from Old Indian Settlement, Casselman, Ont., and an Ermine (*Putorius ermineus*) from Russell, Ont.

D. B. Dowling and L. M. Lambe :—

750 specimens from the Cambro-Silurian rocks of Lake Winnipeg, Man.

L. M. Lambe :—

Fifty specimens of fossils from East Selkirk, and a large "head" of *Cleioocrinus* from Hull, P.Q.

A. P. Low :—

One fossil from Chambord, Lake St. John, Que. One chipped quartz implement, Quebec.

N. J. Giroux :—

About 100 specimens of fossils from the Cambro-Silurian rocks of Quebec.

The additions to the palaeontological, ethnological and zoological departments of the museum, by presentation, exchange or purchase, are as follows :—

By Presentation.

Julian Camsell, Chief Factor, Hudson Bay Co., Mackenzie River district :—

Fine specimen of the Musk Ox (*Ovibos moschatus*) from Fort Rae, Great Slave Lake.

James Fletcher, Ottawa :—

Male Mole Shrew (*Blarina brevicauda*) in the flesh. Six Snow-flakes (*Plectrophenix nivalis*) in the flesh. One Lapland Long-spur (*Calcarius Lapponicus*).

Dr. C. A. White, U.S. Geological Survey, Washington :—

Two specimens of an undermentioned species of *Rhynchonella* found associated with *Aucellæ* at Paskanta, California.

John C. McRae, Port Colborne, Ont. :—

Twenty-five specimens of fossils from the Corniferous Limestone near Port Colborne, two fragments of *Eurypterus* from the Water-lime group at Stonebridge, Ont., eleven specimens of fossils from the St. Louis limestone, and a *Spirifera* from the sub-Carboniferous limestone of Alabama.

Max Klotz, Preston, Ont. :—

Four specimens of *Megalomus Canadensis* from the Guelph limestone, below Preston, on the Grand River.

Donald McKay, Indian Head, N.W.T. :—

Skin of Silver-haired Bat (*Scotophilus noctivagans*) from Indian Head.

W. F. Ganong, Cambridge, Mass. :—

One Starfish (*Asterias Forbesi*) from Oak Bay, Charlotte Co., N.B., and four species of marine Mollusca from the oyster beds of Prince Edward Island.

G. R. White, Ottawa :—

Skin of Grey Gopher (*Spermophilus Richardsoni*).

Prof. H. Alleyne Nicholson, University of Aberdeen, Scotland :—

Named specimens of twenty-one species of Polyzoa from the Trenton, Corniferous and Hamilton formations of Ontario, described or identified by the donor.

H. G. Stanton :—

Specimen of *Miya truncata*, with both valves, from the post-Pliocene of River Beaudette, P.Q.

J. Deans, Victoria, V.I. :—

One specimen of *Monotis subcircularis*, two of *Arniotites Vancouverensis*, from the Trias of Vancouver Island, and phragmocone of a large Belemnite from the Cretaceous rocks of Maud Island, Q.C.I.

S. Robbins, Nanaimo, V.I. :—

Two cores from boring in the Cretaceous rocks (Nanaimo series) of Vancouver Island ; one containing specimens of *Anomia*

Vancouverensis, *Inoceramus mytilopsis*, *Entalis Cooperi* and *Haminea Hornii*.

Captain Josiah Jacques, Victoria, V.I. :—

Burrows of *Teredo* in fossil wood; four species of fossil Pelecypoda and two of Gasteropoda, from near Carmanah Point, V.I.; also one *Conchocele disjuncta* and one *Pachypoma gibberosum*, from post-Pliocene deposits, three miles E. S.-E. of Bonilla Point, V.I.

W. E. Saunders, London, Ont. :—

One small Turtle (*Nanemys guttata*) alive, caught near London, Ont., and one fine living example of Blanding's Box Turtle (*Emys meleagris*, Shaw), from Rondeau, near Chatham.

Colonel C. C. Grant, Hamilton, Ont. :—

Specimen of *Orthis circulus*, Hall, from the Niagara group at Hamilton.

D. Herring, Toronto :—

Female Stilt Sandpiper (*Micropalama himantopus*), from Toronto Island; female Bartramian Sandpiper (*Bartramia longicauda*), shot on the Humber, near Toronto.

S. Herring, Ottawa :—

Four specimens of the Evening Grosbeak (*Coccothraustes vespertina*), shot near Toronto. In the flesh.

Col. Irvine, per Dr. G. M. Dawson :—

One large spear head from the Cypress Hills, Assiniboa.

W. Dickson, per Dr. G. M. Dawson, from the estate of the late sheriff Dickson, Pakenham, Ont. :—

Three adzes from the vicinity of Pakenham, Ont., from his own collection; one fragment of pottery from Long Lake, N.W.T.

R. Têtu, per W. McInnes :—

Two arrow heads from near the mouth of the Cabano River, Lake Temiscouata, Têtu P.O., Que.

D. J. Wing, per D. G. M. Dawson :—

Chisel of jade, from Kamloops, B.C.

George Possie :—

An iron axe.

J. W. Mackay :—

Three black flint arrow heads, from Lillooët, B.C.; one stone scraper, from Spence's Bridge, B.C.; one skin scraper, from Kamloops, B.C.; fragments of shells, teeth and flint from Lytton, B.C.

Walter Odell, Ottawa :—

Eight specimens of sponges and Polyzoa, from the post-Pliocene clays of Odell's brick yard, Ottawa, Ont.

Walter R. Billings, Billings Bridge, Ottawa :—

Eight specimens of *Zygospira deflecta*, Hall, from the Trenton limestone of Division St., Ottawa.

Charles Giramaire, Ottawa :—

One female Short Eared owl (*Asio accipitrinus*) in the flesh.

John Vicars, Cannington, Ont. :—

Skin of a Hoary Bat (*Atalapha cinerea*) from Manitoba.

Dr. Lorenzo G. Yates, Santa Barbara, California :—

Two specimens of the rare *Cypræa spadicea* from the Santa Barbara Channel; three specimens of *Gonostoma Yatesii* from Calaveras Co., Cal., three of *Melania Surati*, from near Cordova, Mexico, and one *Pinna Venturensis*, from the Cretaceous rocks in Ventura Co., Cal.

J. A. Doyón, Ottawa :—

Female Long tailed Duck (*Clangula hyemalis*) in fall plumage.

G. Everett, Ottawa :—

Specimen of the Deer Mouse (*Hesperomys leucopus*) in the flesh.

Dr. H. G. Griffith, Burlington, Iowa :—

Four species of corals and two of Stromatoporoids from the Hamilton shales at Rockford, Iowa.

G. P. Jones :—

Specimen of *Macoma nasuta*, Conrad, brought up on the point of a pile driven fifty feet into the bottom of the Nicomekyl River, B. C.

A. E. Walker, Hamilton, Ont. :—

Petrified specimen of *Mesodon albilabris* from cavities in the Niagara limestone of the mountain at Hamilton.

Dr. P. Jones, Hagersville, Ont. :—

Two otoliths of sheepshead (*Haploidonotus grunniens*) dug up in an Indian ossuary at Hagersville.

Isaac Moore, Ottawa :—

Young Night Heron (*Nycticroax nycticorax nævius*) in the flesh.

By Exchange :

W. Turnbull, Hamilton, Ont. :—

Shells of three species of turtles, nine fossils from the neighbourhood of Hamilton, and one specimen of *Palæotrochus Kearneyi* from the Corniferous limestone of Hagarsville.

G. M. Leslie, Hamilton, Ont. :—

Six species of land shells from the vicinity of Hamilton. A series of vertebræ, ribs, jaws and portions of skulls of snakes, small rodents and insectivora from the upper portion of the gravel ridge at Burlington Heights.

S. W. Howard, J.P., Hagersville, Ont. :—

Seven specimens of fossils from the Corniferous limestone at Hagersville.

S. A. Morgan, B.A., Hagarsville, Ont. :—

One head of *Dalmanites anchiops*, one specimen of *Platystoma lineatum*, two specimens of *Chonetes hemisphærica* from the Corniferous limestone at Hagarsville, and two arrow heads from the same place.

By Purchase :

From John Stewart, Ottawa :—

Two hundred choice and selected specimens of fossils from the Trenton limestone, mostly from the neighbourhood of Ottawa, and from the post-Pliocene of Green's Creek, Gloucester, Ont. Among the former are about seventy remarkably fine, and in many cases unique crinoids, and two specimens representing a new genus of Blastoidea. Among the latter is the most perfect specimen known of the rare fish known as *Cottus uncinatus*, Reinhardt, and several plants not heretofore represented in the museum collection.

Henry Sproule, Ottawa :—

120 fossils from the post-Pliocene nodules of Green's Creek, Gloucester, Ont.

E. Effingham, Cooksville, Ont. :—

Specimen of the Turkey Vulture (*Carthartes aura*), shot at Cooksville, Ont. In the flesh, and since mounted.

G. Hogle, Philipsburg :—

Seven specimens of fossils from the neighbourhood of Philipsburg.

Prof. Henry Ward, Rochester, N.Y. :—

A small series of exotic shells, mostly terrestrial species from the Phillipine Islands.

The entomological collections in the Department are under the care of Mr. James Fletcher. They are contained in nine cabinets, and number about 9,000 specimens. Mr. Fletcher reports :

"The cabinets have been regularly examined, and the collections therein contained are in a good state of preservation, no losses having occurred from insects, mould or accident. Several valuable additions have been made during the year. These are chiefly from the collections made by the officers of the Survey, and by donations. Valuable and extensive collections were brought in by Dr. G. M. Dawson, from the Kamloops district in British Columbia, of Coleoptera and Lepidoptera; by Prof. Macoun, from the Kootanie District in British Columbia, of Lepidoptera and Coleoptera; by Mr. W. McInnes, from the Lake Superior region, of various orders. There are in all these collections many specimens which are interesting additions for the cabinets as well as duplicates for exchange.

"Donations have been received from the following:—

Rev. C. J. S. Bethune, Port Hope, Ont., Coleoptera.

Mr. W. H. Harrington, Ottawa, Coleoptera and Hymenoptera.

Mr. W. H. Darley, Victoria, B.C., Lepidoptera.

Rev. G. W. Taylor, Victoria, B.C., various orders.

Mr. A. L. Poudrier, Victoria, B.C., Lepidoptera from the Rocky Mountains.

Mr. T. E. Bean, Laggan, N.W.T., specimens of rare Lepidoptera.

"Most of these are insects not represented in the collection, and were kindly given in response to an application by the Curator.

"Special cases have been prepared for the exhibition of a collection of native insects in the hall of the Museum, which, it is believed, will be of interest to the many visitors who frequent the Museum."

BOTANY, &c.

Early in the year Professor Macoun was engaged on Part V. of the Catalogue of Canadian Plants, and was also attending to Mr. Pearson's list of Canadian Hepaticæ, then passing through the press; both have since been printed and distributed. Part V. included the ferns and their allies, and an addendum that brought the whole work up to date. One hundred and fifty-five species have been added to the Canadian Flora since the addendum, printed with Part III., was issued.

As the investigation of the fauna and flora of British Columbia had hitherto extended only from the Pacific coast to the Gold Range, Professor Macoun was authorized last spring to make examinations of the Columbia and the Kootanie river valleys and lake districts, and later to make collections amongst the higher summits of the Selkirk and Rocky Mountain ranges. He reports: "This work was successfully carried out. By the first week in April a competent collector was

stationed at Revelstoke on the Columbia river. He worked there for two months, and procured 259 fine skins of rare birds. I joined him early in May and collected in the vicinity of Revelstoke for four weeks, or up to the first of June. My assistant, Jas. M. Macoun, who had remained in Ottawa reading proof and attending to arrears of office work, joined me on that date, and we then went down the Columbia to Deer Park and Sproat, where careful enumerations and collections of the fauna and flora were made. Early in July we crossed the portage from Sproat to Nelson, and spent the next three weeks at various points on Kootanie Lake. We then returned to Revelstoke, and on the 28th of July went to Roger's Pass in the Selkirk Mountains, where some of the highest surrounding peaks were ascended and a number of rare and interesting specimens were secured. Ten days were then spent at Hector, in the Rocky Mountains, and large collections were made on the higher summits around that station. We left Hector for Ottawa on the 20th of August.

To secure data to complete the enumeration of the mosses in Part VI. a three weeks' trip was made in September to the western part of Ontario. The species of that region which had not hitherto been noticed, were collected and recorded. Owen Sound, Windsor, Chatham, Sandwich, Port Dover, Leamington, Port Colborne and the vicinity of Niagara Falls were visited.

The results of the season's work were the addition of over twenty species of birds to the British Columbia Avi-fauna and the addition of many species of flowering plants, part new to science and all new to the Canadian flora. The discoveries in cryptogams, especially mosses, have been so numerous that Dr. Carl Muller, of Halle, says in a letter to Dr. Kindberg, that they constitute a new epoch in American Bryology. Up to the present writing these two gentlemen have named 200 species new to science, collected chiefly by Prof. Macoun during the last three years. About 400 specimens of birds and mammals and 20,000 specimens of plants were collected during the past season.

Since our return from the field my assistant had been engaged in examining and naming the year's collections of flowering plants, getting out the species to mount and doing the general work of the office, while I have been occupied on Part VI. of the Catalogue of Plants and on the Catalogue of Canadian Birds, which is approaching completion. All work in connection with the Herbarium has been done as in the previous year, 1889, by Mr. Jas. M. Macoun. During 1890, 3,807 sheets of specimens have been mounted and placed in the herbarium. Of these 2,316 were flowering plants and 1,491 cryptogams, principally mosses. Of the flowering plants 1,699 were Canadian, 260 from the United States, and 457 from Europe.

4,211 sheets of specimens were sent from the herbarium to private individuals and to public institutions in exchange for desiderata; of these 1,871 were cryptogams and 2,340 flowering plants. Specimens were sent to

The British Museum.....	200
Central Experimental Farm, Ottawa.....	200
Mechanics Institute, Wingham.....	100
St. John's College, Winnipeg.....	100
Department of Public Instruction, Quebec.....	100
McGill College, Montreal.....	100
National Museum, Washington.....	200
University of Nebraska.....	124
Harvard University.....	164
California Academy of Science.....	100
Shaw School of Botany, St. Louis, Missouri.....	170
Columbia College, New York.....	218
The University of Copenhagen, 100 flowers, 400 cryptogams.....	500
Professor Kindberg, Linkoping, Sweden.....	884

Since the 31st of December, 1889, in connection with the work of this division, 447 letters of sufficient importance to copy were written, and about the same number were received.

Since returning from the field the herbarium of St. Laurent College, Quebec, has been examined, and the specimens, over 2,100, named; also the herbarium of Mr. Morten, of Wingham, and Dr. White, of Toronto, besides many small collections from various parts of the Dominion.

The survey herbarium is arranged in eight large cases, but these are now so full that specimens are frequently injured by being crushed; another case will shortly be available and a better arrangement of the specimens will then be effected, and they will be much better preserved.

Considerable inconvenience is now caused by the crowded state of the small room devoted to the work of this division. It arises from the accumulation of the large collections annually brought in, and it is hoped that the alterations that have been suggested, whereby this serious inconvenience would be in a measure obviated, will be speedily carried out.

The following notices from foreign journals indicate the estimation and appreciation of the botanical work of the division under Professor Macoun :

From "Zoe," (Vol. 1-9) a biographical journal published at San Francisco—

"Catalogue of Canadian Plants, Part V. This part contains the ferns and fern allies and additions and corrections to Vol. I-IV., which are rather extensive, embracing a hundred pages and conforming to recent revisions. * * * The work in general has been carefully done and reflects credit upon the Government of Canada and the botanists concerned in its production."

From "Botanical Gazette," Vol. XVI. :—

"With the appearance of Part V., devoted to Pteridophytes, Prof. John Macoun's Catalogue of vascular Canadian Plants has been completed. It has been very handsomely done, and the painstaking care so evident through it all has made it a mine of information concerning the Canadian Flora. A large appendix brings together additions and corrections to Parts I-IV., the results of all monographic work done since the beginning of the catalogue being included. * * * The part is rounded out by a complete index to all the parts, and the five will make a very complete and compact volume."

MAPS.

Maps in course of Preparation and Published during 1890.

North-west Territory, 9 sheets, 20 to 26 inches long by 16 inches broad, showing waters followed by the members of the Yukon Expedition, 1887-88, and reaching from longitude 111° to 144° and latitude 59° to 68°, to accompany report by Mr. McConnell, will be ready for engraver in two months.....	8 miles=1 inch.	
Index map of the above now in the litho- grapher's hands.....	48 miles=1 inch.	
British Columbia, part of southern interior (Dr. Dawson), in draughtsman's hands, will be ready for engraver in April....	4 miles=1 inch.	6,400
British Columbia, Kootanie district (Dr. Dawson), published 1890.....	8 miles=1 inch.	11,000
British Columbia, Shuswap district (Dr. Dawson), in draughtsman's hands.....	4 miles=1 inch.	6,400
Manitoba, map taking in the whole of Lake Winnipeg (Mr. Tyrrell) in the draughtsman's hands.....	do	48,600
Northern Manitoba, in manuscript (Mr. Tyrrell).....	2 miles=1 inch.	5,000

Northern Manitoba, in engraver's hands (Mr. Tyrrell).....	8 miles=1 inch.	20,000
Western Ontario, Lake of the Woods, sheet No. 2, in the engraver's hands... .	2 miles=1 inch.	2,000
Western Ontario, Hunters Island, sheet No. 7, (Dr. Lawson) in the engraver's hands.....	4 miles=1 inch.	1,450
Western Ontario, north of Hunters Island, sheet No. 6, in draughtsman's hands.. .	do	3,456
Ontario, sheet No. 130, Sudbury Mining district (Dr. Bell), in hands of draughts- man; will be ready for engraver in a few weeks.....	do	3,456
Ontario, sheet No. 115, ready for draughts- man.....	do	3,456
Ontario, general map in progress.....	do	
Quebec, N.E. $\frac{1}{4}$ sheet (Eastern Townships map) in hands of engraver.....	do	4,500
Quebec, S.W. $\frac{1}{4}$ sheet (Eastern Townships map) in draughtsman's hands.....	do	4,500
Quebec, N.W. $\frac{1}{4}$ sheet (Eastern Townships map) in progress.....	do	4,500
Quebec, Quebec and Lake St. John dis- trict, $2\frac{1}{4}$ sheets in progress.....	do	6,912
Quebec, $\frac{1}{4}$ sheet, 18 S.E. and 18 N.E. (Messrs. Bailey & McInnes) in draughts- man's hands.....	do	3,950
Quebec, Lièvre River and Templeton Phos- phate region, Ottawa county, 2 sheets (Mr. Ingall), will be ready for engraver in two months.....	40 chains=1 inch.	220
New Brunswick, surface geology, $\frac{1}{4}$ sheet 1 S.W., 1 S.E. and 1 N.E., 3 sheets (Mr. Chalmers), ready for engraver in a month.....	4 miles=1 inch.	6,650
Nova Scotia, $\frac{1}{4}$ sheet, 11 N.W. and 11 S. W. in the engraver's hands.....	do	
Nova Scotia, $\frac{1}{4}$ sheet, 4 N.E. and 4 S.E., (Messrs. Fletcher and Faribault) in manuscript, most part of them drawn.. .	1 inch=1 mile.	

LIBRARY, SALES AND DISTRIBUTION OF PUBLICATIONS.

Dr. Thorburn reports that the distribution of the various publications of the Geological Survey Department with which he is charged has now attained large dimensions and is likely to increase year by year. Last year there was sent from the office, including Annual Reports, special Reports and maps, 8,936. This is exclusive of the annual Report Vol. III., 1887-88 in French, the printing of which has unfortunately been delayed. There have been distributed in Canada 6,527, the remainder, 2,409, were sent to foreign countries, to scientific and literary institutions and individuals in the various countries of Europe, India, China, Japan, Australia, the United States, etc.

There have been received as exchanges during 1890, 2,375 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps.

The books purchased during the year were 116, and 41 periodicals have been subscribed for.

The number of books bound during the same period has been 152. Now that the work of binding has been taken over by the Government, it is hoped that it will, in future, be done as promptly as is desirable, and indeed essential that it should be, to make the volumes accessible to the members of the staff who are constantly requiring them for consultation and reference.

As an evidence of the amount of work connected with matters relating to the library, and to the distribution of the Geological Survey publications, it may be stated that during the past year 1,644 letters were sent by the Librarian and 2,476 were received by him, as compared with 1,511 and 1,256 in 1889.

The number of volumes in the library is now about 8,500, and of pamphlets, 3,300.

In the Report for 1886, it was stated that a card catalogue of the library had been introduced. It has been in operation ever since and has been found to be of great service in assisting members of the staff in finding, more readily than formerly, information on the various subjects under investigation.

For several years past, the space allotted to the library has been found to be altogether insufficient, and consequently a large number of books are not readily available for reference, except at a great inconvenience of those wishing to consult them. It is to be hoped that this will be soon remedied so that a full and exhaustive classification may be made.

Sales of Survey publications for year ending 31st December, 1890, amounted to \$2,366.42.

VISITORS.

The number of visitors to the Museum during the year, from 1st January to the 31st December, was 17,760.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The staff at present employed is 52, viz.: professional, 34; ordinary, 18.

During the year the following changes in the permanent staff have taken place:—

Dr. A. C. Lawson, field geologist, resigned.
 Mr. Amos Bowman do do
 Mr. F. G. Wait, appointed assistant chemist.
 Mr. L. N. Richard, appointed draughtsman.
 Mr. J. B. Tyrrell, promoted from 2nd to the 1st class.
 Mr. R. L. Broadbent do 3rd do 2nd do
 Mr. H. M. Ami do 3rd do 2nd do

The amount available for the fiscal year ended 30th June, 1890, was:

—	Grant.	Expenditure.
	\$ cts.	\$ cts.
Civil list appropriation.....	45,750 00	
General purpose appropriation.....	62,100 00	
Civil list salaries.....		40,768 78
Wages of temporary employees.....		17,051 85
Exploration and survey.....		22,528 01
Printing and lithography.....		13,520 83
Boring operations, Deloraine.....		2,497 54
Purchase and binding of books, etc., and purchase of instruments.....		1,232 80
Purchase of specimens.....		814 57
Laboratory apparatus and chemicals.....		238 34
Stationery, mapping materials, and Queen's Printer.....		1,216 45
Incidental and other expenses.....		2,488 09
		102,357 26
LESS—Paid in 1889.....		6,026 93
		96,330 33
ADD—Advances to field explorers.....		6,534 66
		102,864 99
Unexpended balance, civil list appropriation.....		4,981 22
do general purpose appropriation.....		3 79
	107,850 00	107,850 00

The correspondence of the Department shows a total of 11,159 letters sent and 6,016 received.

I have the honour to be sir,

Your obedient servant,

ALFRED R. C. SELWYN,

Deputy-Head and Director.

GEOLOGICAL SURVEY DEPARTMENT
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

SUMMARY REPORTS

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1891

BY

THE DIRECTOR



PUBLISHED BY AUTHORITY OF PARLIAMENT

OTTAWA :

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S
MOST EXCELLENT MAJESTY

1892

SUMMARY REPORTS
ON THE
OPERATIONS OF THE GEOLOGICAL SURVEY
FOR THE YEAR 1891

GEOLOGICAL SURVEY DEPARTMENT,
OTTAWA, December, 1891.

The Hon. EDGAR DEWDNEY,
Minister of the Interior.

SIR,—In presenting the Summary Report of the proceedings and work of the Department, as required by section 6 of the Act 53 Victoria, chap. XI, it is gratifying to be able to again record the substantial and satisfactory progress that has been achieved during the year now closed, and it is even more so, to be able to ascribe it largely to the increasing interest in the work, evinced by the members of the staff, as shown by the painstaking perseverance with which they are devoting their best energies to investigating, often under very adverse circumstances, depicting and describing the diverse and often intricate geological phenomena presented throughout the Dominion, and more especially in endeavouring to decipher what the bearing of these phenomena is and what they teach, in reference to the profitable development of the mines and mining industries of the country. Thus one or other of the members of the field staff of the Department is in a position to give intending investors and the public the most reliable, authentic and entirely disinterested information respecting mines and minerals in all parts of Canada. Notwithstanding these facts, however, we find that in most cases the opinion of some so-called, often self-styled “mining expert” or “practical miner” from Europe or the United States, is sought and acted upon in preference to that of a member of the geological corps who is thoroughly acquainted with the geological structure of the district in which the information is desired. These “expert” and “practical” opinions rarely prove correct, and their first cost, often considerable, is by no means the greatest. Not a year passes unmarked by such cases and the past season is no exception.

The boring for gas at Stewarton in 1889; for water at Morden in 1890; for gas at Belleville in 1891; and for oil near Pincher Creek the past summer, are some of the instances of such useless expenditures, all of which might have been saved had the advice of the Department been sought and followed, instead of that of "expert" opinion.

In this connection and as showing the proper functions, not generally understood, of a geological survey and an associated museum, I may be permitted to quote the following remarks from "Science," No. 464, December, 1891:—

"A geological survey, if properly organized, is composed of professional men of scientific attainments and of undoubted integrity; it is an official organization, and its examinations are made disinterestedly, and on the truthfulness of its results depends the reputation of its members. Its publications are widely circulated; they are designed to be used by the professional man and also by the layman; being official, and coming from such a disinterested source, the results are accepted generally without hesitation by the capitalists or manufacturers. Such influence and acceptance could never be reached by reports emanating from owners of property or other interested parties, nor would the judgment of such concerning theories of distribution or quality command respect unless emanating from well-known expert sources; thus the capital and enterprise necessary for the inception of such undertakings would be slow to follow such guidance. Hence, a good geological survey constitutes the best of advertising mediums, if you choose to call it such; advertising what is genuine and good, but never stooping to indiscriminate booming.

"But another means of disseminating information exists, over and above that of publications. Some people are not reached by reports, either because they are not given much to reading, or for lack of access to the publications. They may come to the state, or even be in the state, knowing little or nothing of its natural features and products. In such cases, a State Museum is the most effective means of conveying information; a museum which shall contain not only specimens of materials, but maps, models, views, diagrams and reports concerning all that is of interest in this connection; the materials in which shall be so arranged as to convey clear ideas, not only of what is in the state, but where it is, how it occurs, and how much there is of it; which shall be supplemented by the presence of trained men, familiar with the state, who can guide the stranger in the right direction.

"In conclusion, I would say a few words concerning the educating influences of a geological survey among the citizens of the area in

which it operates. Through its publications, through the intercourse with its members, and in other ways, a vast amount of information is absorbed by the people concerning the land they live in and its products. This information they apply unconsciously in their various operations. It prevents them from being led into hopeless enterprises, it leads them to discountenance extravagant expectations and to recognize charlatanry, it brings them to appreciate the truly useful and valuable, and it supplies them with a source of advice which many are otherwise destitute of."

The foregoing description of the proper functions, educating influences and general usefulness of such an institution, is worthy of the attention and careful consideration of the public and especially of those in whose hands it rests to find the means for its establishment and support.

The early part of the year was as usual fully occupied by the members of the survey in the preparation of maps and reports and in the critical examination and classification of the numerous specimens—rocks, minerals, fossils, plants and insects—collected in the field. In the divisions of lithology, palæontology, botany and entomology valuable, gratuitous assistance has been rendered the survey by the following United States and European scientists :—

Professor G. H. Williams, of Baltimore, O.

Professor Cope, of Philadelphia, Pa.

Mr. S. H. Scudder, of Cambridge, Mass.

Professor T. Rupert Jones, London, England.

Professor H. Alleyne Nicholson, Aberdeen, Scotland.

Dr. N. C. Kindberg, Sweden.

Dr. Carl Müller, Germany.

Mr. C. Warnstorff, Germany.

Mr. C. Lyman, of Montreal.

To all of these gentlemen the best thanks of the Geological Survey of Canada are due and I have much pleasure in thus officially tendering the same.

Mr. James Fletcher has also added to his already onerous duties in connection with the experimental farm, the honorary curatorship of the entomological collection in the museum of the Geological Survey, and has devoted no little time to its arrangement and care.

In my last Summary Report, page 7, I referred to the annual report Vol. IV and mentioned seven of the parts then issued. The volume has since been issued. It contains ten separate reports, which with illustrations and maps, table of contents and index, constitutes a work of some 1082 pages R. 8vo. The detailed reports which will form

Vol. V of the annual reports are well advanced and the volume will probably be issued before the close of the present year.

As in previous years the geological investigations were carried on in all the provinces of the Dominion, either in the direction of revising and adding to the details of portions of districts that had already been examined and reported on, or in exploring and mapping districts in which no detail had hitherto been secured.

The working parties, 20 in number, were distributed as follows :—

British Columbia	1	Quebec	5
Alberta	1	New Brunswick	1
Manitoba	2	Nova Scotia	3
Ontario	7		

In addition to these, explorations were made by Professor Macoun and by Messrs. Ami, Weston and Willimott for collecting in Botany and Zoology, Palæontology and Mineralogy.

From the summary statements herewith presented, it will be seen that Professors Bailey, Adams and Laflamme were only a short time in the field, during vacation, and Mr. McConnell only during the month of June, while nearly the whole of Dr. G. M. Dawson's time had to be devoted to work in connection with the Behring Sea Commission.

A large part of my own time during the year has, as usual, been occupied in editing reports, in correspondence and in attending to the executive details of the Department, including those of the Survey and the Museum.

On the 11th of March I received a communication from Mr. Beauchemin, of St. Hyacinthe, informing me of the discovery of natural gas in that vicinity. On page 34A of my Summary Report for 1887, referring to this subject, I wrote : "While for reasons connected with this—the geological structure—I have never had any faith in their occurrence on the north side of the St. Lawrence, I consider that the probability of such reservoirs existing on the south side, in the country between Lake St. Peter and St. Hyacinthe, is very great."

In reply to Mr. Beauchemin's letter, I communicated the above to him, and that I would take an early opportunity to visit the locality. I was unable, however, to do so till the 7th of July, when I proceeded to St. Hyacinthe, and accompanied by Mr. Beauchemin and Mr. Desaulier, I visited the several sites where gas was reported. The first examined was on the farm of Antoine Laplante, about six miles north of St. Hyacinthe, on the concession St. Amable, two miles south-west of the village of St. Barnabé, and the same distance west of the Richelieu river. Here Laplante had recently, with the aid of a small

hand-boring tool, succeeded in reaching the rock at a depth of 90 feet, a continuous, though not large, flow of gas being the result. The material penetrated consisted entirely of clay, with some small stones near the bottom. This boulder clay covers and almost entirely conceals the older rocks, and forms the level surface of the great plain of the Richelieu and Yamaska rivers. A pipe $1\frac{1}{2}$ inch diameter had been inserted in the hole, and a continuous, though not powerful, flow of gas was coming from it. On inquiry, I found that within a radius of 400 yards from this well, there were four places, sites of old wells, where gas is escaping. One of these was sunk 45 years ago, and the gas has been escaping ever since. The others are more or less recent trials for water, and have penetrated to rock through from 85 to 100 feet of clay, and in all gas comes from the bottom. In three, an inch and a-half pipe has been inserted, and the escaping gas ignites readily and burns steadily, but the pressure is light. On lot No. 18, parish of St. Hyacinthe, range St. Francis, on the farm of Emile Lorquet, close on the east side of the railway to Farnham, I also found gas escaping in a similar manner from a small pit sunk about two feet into the black soil. Near this two wells had been sunk, one 150 yards east, 106 feet deep, the other about 500 yards north, 110 feet deep, and in both, I was informed, gas had been encountered at the bottom. The sinking was through clay, like that in the bore holes on the St. Amable concession, which lies about eleven miles nearly due north, and on the other, or west, side of the Yamaska river.

These facts, in connection with what I wrote in my summary report for 1887, above referred to, are certainly interesting, but by no means sufficient to warrant any positive assertion respecting the success or otherwise of an attempt to find extensive gas or oil reservoirs in the Trenton or other Cambro-Silurian formations, which underlie the great plain of the Richelieu and Yamaska rivers, between Sorel and St. Hyacinthe. There are no surface indications in the area which would indicate any particular site as the most favourable. Under these circumstances the vicinity of, or on, the St. Amable concession is the locality I would suggest as that where a trial should be made. If successful, the cost of piping the gas to St. Hyacinthe would be a trifle in comparison with its value for heating and lighting purposes.

On Friday, the 10th of April, I left Montreal for Deloraine, Manitoba, to make arrangements with the contractor there, to continue the boring. On arriving at Deloraine, on the 17th of April, I found the boring had attained the depth of 1,740 feet, without any material change in the character of the strata from that stated page 9 of my Summary Report for 1890.

After discussing the situation with the local boring committee and the contractor it was arranged to continue the work. Various unexpected and unavoidable delays and difficulties have, however, since arisen, notwithstanding every effort on the part of the contractor, so that on the 31st of December a depth of only 1,808 feet had been reached. There is, however, still every reason to believe that a successful result will be attained so soon as the base of the impermeable clay shales is reached.

Since the date of my last report the expenditure has been \$6,846.18, making a total to 31st December, 1891, of \$15,494.80.

The undertaking is of national importance and should certainly be prosecuted in spite of the unfortunate accidents and delays that have occurred, until either a negative or affirmative result is attained.

I left Deloraine on the 20th of April, the 22nd was spent at Schreiber in an examination of the cuttings, in the forenoon, four miles west, and in the afternoon, two miles and a half east, and to the openings lately made on a deposit of pyrrhotite precisely like those of Sudbury and occurring on the border of a mass of diabase, associated, as at Sudbury, with schists breccias and some white granite rock, this latter being well seen near both ends of the first trestle east of Schreiber. The analysis of the samples of the ore that were collected gave only .003 per cent of nickel, but as in all these deposits the nickel is very unevenly distributed an analysis of a few small samples is of little value as an index of the contents of the whole body. At the date of my visit the snow was still thick in the woods, and I was not able to do more than ascertain that the area over which the pyrrhotite occurred was more than sufficient to constitute a good mine, and was very favourably situated for working. The deposit was, I believe, opened by Messrs. Marks, of Port Arthur, towards the close of 1890. I cannot learn that any work has been done on it since the date of my visit in April last.

The northern limit of the area of Huronian rocks, which extends from about four miles west of Schreiber, eastward, for about sixty or seventy miles, has not yet been traced out, nor has that other large area crossed by the Canadian Pacific railway between White River and Dalton stations.

It is important that this should be done so as to be able to indicate those portions of it which should be carefully explored for valuable economic minerals. With a view to comparing the rocks of these areas with those of Sudbury, I devoted several days, from the 5th to the 11th of September, to an examination of the cuttings on the line of the railway from east of the Pic River bridge to near Schreiber.

Much of it is occupied by massive gabbro, diabase and red quartz syenite, and it is in and around the borders of these crystalline rocks, especially the former, that the nickeliferous deposits should be looked for. The fine samples of zinc ore that were exhibited at the Colonial and Indian Exhibition in 1886, were derived from one of these diorite masses which lies about twelve miles north, a little east, from Rossport station, and which may be connected with the Schreiber Huronian area.

On the 13th of July I left Ottawa for Pincher Creek, Southern Alberta, and arrived there on the 19th *via* Lethbridge and Macleod. My object was to visit and examine the reported discoveries of petroleum in that vicinity and in the South Kootenay pass, as well as the coal seams discovered in the Crow's Nest pass. The petroleum discovery was incorrectly referred to on page 13 of my last Summary Report as being in the Crow's Nest pass, and it was stated that circumstances had then prevented me from carrying out my intention of visiting the locality. On the present occasion all necessary arrangements had been made for men and horses to meet me at Pincher Creek, and these arrived there from the west the same afternoon.

I found considerable excitement existed in the village, in fact, a decided "boom" in petroleum claims, and that a company had been formed to put down a boring, the site selected for the experiment being on sec. 21, township 3, range 29, some 18 miles south, a little east, of Pincher Creek village.

On Monday the 20th of July I proceeded to the locality named, accompanied by several gentlemen interested in the work. The country traversed is fine farming land, a richly grassed undulating prairie well watered by numerous small tributaries of Pincher creek and the Waterton river, all of which eventually find their way to the Saskatchewan. The site of the proposed boring was on a small flat on the left bank of one of the tributaries of Waterton river. A gang of men were at work erecting a derrick and preparing to put an engine and boiler, already on the ground, in place.

The evening of the 20th of July and the whole of the following day was devoted to an examination of the rocks that were exposed in the creek both below and above the site selected for boring. They were ordinary varieties of sandstone and sandy shales of the Cretaceous, with irregular dips from 15° to 20° . The last exposure of these rocks up the creek, was about three miles and a quarter, then, for about three miles further there were no exposures up to where the creek emerges from a rocky gorge, all along which there are good exposures of hard flinty red, green and grey shales and sandstones often gritty and

quartzose and dipping to south-south-west at 25° to 30° . These are the Cambrian rocks which here form the base of the eastern spurs and ridges of the Rocky mountains. It was stated that both in this gorge and at several places in pools on the prairie to the eastward petroleum had been seen, but no one at the boring camp could show me any of these places.

The whole country for many miles around and up into the entrance of the South Kootenay pass, nine miles to the south, was marked off with the stakes of the oil claims. On inquiry, I was informed that an "expert" named Baring had been there and had expressed a favourable opinion as to boring where operations were being commenced. I was unable to learn any other reason for fixing on the site. The note I made under date 21st of July reads: "There is nothing whatever to indicate the existence of petroleum in this vicinity. It seems highly improbable that it should be found here, though, of course, not impossible." I subsequently heard that a copious flow of water had been struck and the boring abandoned. The cost of this very absurd and useless operation must have been considerable.

On the 22nd of July, I left the boring camp and proceeded about eight miles in a southerly direction, gradually approaching the foot of the mountains, till we struck the Kootenay branch of the Waterton river, which here leaves the South Kootenay or Boundary pass. This stream was then followed up about two miles and a-half, where we camped on the left bank, opposite a depression in the high range which here borders the pass on its southern side, and divides the waters of the Kootenay branch from those of "Cameron Falls" creek. An ascent of about two miles by a somewhat rough trail mostly over grey and white heavy bedded dolomites brought us to the summit of this depression. We then descended into the valley of Cameron Falls creek. This creek takes its rise in a small lake near Camp Akamina of the boundary survey and flows north-east about seven miles to where we struck it, and where it makes an almost right angle bend and flows south-east into Waterton lake.

Camp Akamina is thus described by Dr. G. M. Dawson: "The spot known as Camp Akamina, the eastern terminal station of the old North-West boundary commission, is situated at the head of the valley just described. It has an elevation of about 6,000 feet above the sea, and is a sheltered hollow characterized by thick spruce woods of fine growth. The boundary cairn is placed on the watershed about a mile from the camp, and though built thirteen years ago was found in perfect preservation. It is important as marking not only the forty-ninth parallel or boundary between British North America and the

United States, but as lying at the adjacent angles of British Columbia and the as yet unorganized North-West Territory."*

A full description is also given in the same chapter of the character of the rocks and the appearance of the country.

Cameron Falls brook is a rapid mountain stream, eight or ten yards wide. After following it up about a mile and a-half on the left bank, Mr. Fernie, my guide, remarked that we must be close to where the oil had been found. He had scarcely spoken when, while still in the saddle and on the trail eight or nine feet above the brook, I noticed a powerful odour of petroleum. Descending to the edge of the water and stirring the stones and gravel in the bed of the stream, considerable quantities of oil at once rose to the surface and floated away. Crossing to the right bank it was again seen coming out of the bank, some inches above the then level of the stream. Here, skinning it off the surface of a shallow pool, a wine bottle full was soon collected. This can now be seen in the Geological Survey Museum. Sixty or seventy yards below where the oil was seen, a rocky reef of grey siliceous dolomite crosses the creek and rises into a steep bluff on the left bank; on the right bank, seven or eight feet above the creek, a broad thickly timbered flat extends for 150 yards to the base of the bordering mountains which culminate six miles to the south-west at the boundary monument, 6,000 feet above sea level.

No work whatever had been done to test the nature of the oil sources. A comparatively small outlay for some shallow sinking or boring on the flat above described would do this.

On the 23rd, we proceeded through the pass, crossing the summit and camping on Akamina brook about six miles down on the western slope in British Columbia. On the 24th we proceeded down the valley and at about four miles north of the 49th parallel the trail came down to the level of the brook, and here on the edge of a beaver dam pool there were ledges of hard dark blue shale dipping E. 30° N. 12°. Lifting layers of this at and below the water a quantity of dark green circular patches of oil rose to the surface, and a precisely similar result followed by stirring up the mud in the bottom of the pool. This place is about fifteen miles in a direct line, west 10° south, from the occurrence on Cameron Falls creek, the main watershed of the Rocky Mountains and Mounts Kirby, Spence, and Yarrell intervening. Oil is said, by the Indians (the Stoney) who frequent this region, to occur at other points, in the Akamina Brook valley, both above and below that recorded. The Akamina joins the Flathead river in Montana,

*Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Parallel, Chap. III.

about four miles south of the international boundary. The Beaver dam oil is of a dark greenish black and does not apparently differ much from that of Cameron Falls creek. Preliminary tests might be made here by sinking a shallow shaft in the shales at the Beaver dam pool, and by a boring on the sandy and gravelly flat country about two miles and a-half north of the boundary line.

On the 24th of July we camped in Montana on the left bank of the Flathead river, about two miles above the mouth of the Akamina or Kish-e-ne-nah creek.

On the 25th we proceeded up the Flathead valley, the trail passing for the most part along high terraces of sand, clay and gravel. At 8 a.m. we recrossed the boundary on one of these terraces and then again descended to the river where we off saddled and waited for the pack train. It arrived at 10.30; and we then ascended again to the high level terrace and turning north crossed a number of ridges and gullies into the valley of Sage creek camping on the right bank at about nine miles above its mouth.

At about a mile and a-half higher up, the creek leaves the high mountains which border its upper course in a north-easterly direction up to the main watershed some twelve or fourteen miles distant, and here at the edge of the water, on the left bank, I found hard dark flinty shales like those at the Beaver dam pool on the Akamina dipping S. 25° — 30° W. $< 25^{\circ}$. Directly the layers of this rock are raised the oil rises and spreads over the surface of the water in such abundance that a short time suffices with the aid of a tin cup to collect a bottle full. Here, also a considerable quantity of gas escapes from the cracks and joints in the rock and ignites freely on the application of a match.

Less than half a mile higher up, on the right bank and on the opposite or west side of the valley, oil was again found issuing from the base of a bank of drift which has here filled the valley and caused the stream to make a sharp bend eastward to the base of the opposite mountain. No rock was exposed here, but every stone in the bed of the creek, especially on being broken or rubbed, gave out a strong odour of petroleum. The oil collected here, a sample of which can be seen in the museum, differs entirely in appearance from those of Cameron Falls creek and Akamina or Kish-e-ne-nah creek.

Some of it was of a light lemon yellow, but most of it nearly the colour of pale brandy and with a very powerful petroleum odour.

The general geological structure, the character of the rocks and the physical aspect of the country in the South Kootenay, the North Kootenay and the Crow's Nest and other passes of the Rocky moun-

tains have been admirably described by Dr. G. M. Dawson,* and the South Kootenay pass is also described in his Report on the Geology and Resources of the Forty-ninth Parallel, 1875. For details on the subjects named these works can be referred to. The present is, however, I believe the first recorded instance of the occurrence of petroleum in this region, as well as of its occurrence in Cambrian rocks. Whether the reference of the rocks to this age is correct, is not quite certain ; that it is so as regards the somewhat similar siliceous dolomites and quartzose strata of the Kicking Horse pass has been proved by the discovery of a Cambrian fauna and there seems no reason to doubt that the petroleum-bearing beds of the South Kootenay pass are of the same age. At present, however, except on the traverses made by Dr. Dawson, little or nothing is known respecting the distribution of the formations in the great block of mountainous country which lies between the 49th and 51st parallels of latitude and the 115th and 117th degrees of longitude, and which comprises the Purcell, Hughes, Macdonald and Galton ranges and covers an area of about 9,600 square miles, much of it densely wooded and with peaks ranging to eight and nine thousand feet.

Leaving Sage creek we followed up the Flathead valley crossing and recrossing the river and its numerous channels so frequently that we travelled almost as much in the water as on the land. On Tuesday, the 28th of July, we travelled in this manner for ten hours without a halt, and at 6 p.m. camped on a fine grassy flat, surrounded by timber, at the foot of the abrupt ascent from the Flathead valley to the eastern summit of the North Kootenay pass.†

On the 30th of July, we camped at Lee's lake on the Crow's Nest pass trail. On the 31st Col. Baker joined me here, and on the following day we camped at the east end of Crow's Nest lake, and on the next day, 2nd of August, we reached the coal prospecting camp situated about 1,200 feet above the trail, on the ridge which runs in a north easterly direction between Marten creek and Michel creek and forms the west side of the valley of the west branch of Michel creek. From this ridge a number of spurs with steep intervening gullies descend abruptly to the trail ; in these and on the intervening ridges a wonderful series of coal seams is disclosed, one above the other from near the level of the trail to the summit of the ridge.

No exact measurements were taken and it may be that some of the lower cannel seams are the upper ones repeated by faulting. The out-

*Annual Report Geological Survey, 1885.

†Annual Report Geological Survey, 1865, p. 61 *b et seq.*

outcrops which can all be seen on the ground are as follows, twenty seams in all, showing a total thickness of 132 feet of coal:

	Feet.
No. 1.....	5
2.....	3
3.....	4
4.....	2
5.....	4
6.....	3
7.....	2
8.....	4
9.....	5
10.....	6
11.....	4
12 (Peter seam)	15
13.....	7
14 (Selwyn seam)	6
15 (Jubilee do)	30
16 (Williams seam)	20
17.....	5
18.....	3
19.....	2
20.....	2

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The number and thickness of these seams in the above table are as supplied me by Mr. Fernie, who has superintended all the exploratory work that has been done on the seams. Between the most eastern outcrops I examined, and the western ones close to the junction of Marten creek and the west branch of Michel creek, is a distance of about two miles along the steep mountain side, to the north of the trail. Within this distance the outcrops were seen of nearly all these seams, either on the ridges or in the sides of the ravines which score the face of the mountain. The few hours I was able to spend on the ground, while not sufficient to enable me to affirm the absolute correctness of the details of the table, were, however, ample to enable me to see that there is in the Crow's Nest pass, between the eastern summit, 4,330 feet above tide, and the valley of Elk river, in British Columbia, an area of not less than 144 square miles, that is destined to be one of the most valuable and most productive coal fields in Canada. A rough calculation would give about 49,952,000 tons per square mile. If one-half of this is available there are in each square mile 24,976,000 tons. The average elevation of the field is about the same as that of Canmore and Banff, or between 4,000 and 5,000 feet. From Pincher Creek westward to Elk river, the pass presents no difficulties for railway construction. The eastern entrance to the pass in Alberta is

3,800 feet, and where it comes out on the Elk river is 3,300 feet ; the highest intervening summit being 5,500 feet. A better route to the Elk river, however, than that of the present trail, would be to follow down Michel creek, from near the eastern summit and thus avoid the western and higher summit, and reach Elk river about ten miles above the mouth of Coal creek. The distance through the pass from Lee's lake, Alberta, to the Elk river, is about thirty-seven miles.

On the 4th of August, after devoting the forenoon to a further examination of the Marten creek seams, we proceeded through the pass and reached Elk river at 6 p.m. No coal seams were seen till about four miles above the mouth of Coal creek ; here at the mouth of a steep rocky gulley, about 200 yards to the right of the trail, a fine seam of coal, 7 feet thick, had been cut into. The section exposed showed in descending order :

Shale.....	10	feet.
Hard ferruginous band.....	1·	
<i>Coal</i>	1·6	
Shale.....	7·6	
<i>Coal</i>	7·6	

Cherty conglomerate and massive gritty sandstones are seen both above and below ; the dip is about E. 10° N. 15°—20°. A close search along the mountain side, between here and the water-shed at the head of Coal creek, would almost certainly disclose the outcrops of many more of the Marten creek seams.

On the 5th of August, we descended the Elk river valley, about seven miles, then turning to the left ascended the mountain, a steep climb of 1,500 feet. Here on top of a broken-down cliff of massive sandstone, about 50 feet thick, we came to the first of a series of coal seams ; the dip being E. 20° N. 35° and the seam 25 to 30 feet thick, with a shale parting about 2 feet ; bar. 24·93. Ascending 130 feet over shales and brown thick bedded sandstone forming a similar broken-down cliff of about 50 feet, a second seam of coal was reached, also 30 feet thick ; bar. 24·80. Above this four more seams were examined :

No. 3	15	feet, bar.	24·57
4	4	do do	24·50
5	7	do do	24·42
6	30	do do	24·35

Above No. 6 there are six more seams which were not visited, but the particulars of which given me by Mr. Fernie are as follows :—

No. 7	10	feet—100	feet from	No. 6
8	4	do	100	do
9	7	do	100	do

No. 10	2 feet—	100 feet from No. 9
11	7 do 100	do 10
12	4 do 200	do 11

The distances are approximate only, they have not been measured.

The above gives a total thickness of 148 feet of coal against 132 feet in the Marten creek area on the eastern side of the basin, while in other respects the seams correspond so closely as to make it almost certain that, except where cut out in the valleys, they are continuous beneath the whole intervening area. For much detailed information respecting the Crow's Nest pass the Annual Report of the Geological Survey, Vol. 1, part B, 1885, already cited, and the accompanying map, can be referred to.

Many of the seams are first-class coking coals and others are good gas coals, but none of them are anthracites. For analyses of those of the Jubilee and Peter seams, Marten Creek, See Annual Report Geological Survey, Vol. III, Part II, pp. 12 s. to 15 s., and for those of the "cannel" seams, Vol. IV, pp. 7 r. and 8 n.

On the 6th of August I reached Pincher Creek, and Ottawa on the 14th.

Dr. G. M. Dawson was employed during the earlier part of the present year in working up and preparing for publication the information intended to be included in the Kamloops sheet of the geological map of British Columbia and had made preparations to undertake some special examinations in the foot-hills of the Rocky Mountains and to continue the field work already begun in the adjacent Shuswap sheet during the summer. Before leaving for this work, however, he was appointed as one of the British Behring sea commissioners, and arrangements had consequently to be made such as to enable Mr. McEvoy to continue the work on the Shuswap sheet on the general plan already adopted, while Dr. Dawson was left free to devote himself for the time to the special enquiry just referred to. The completion of the Kamloops sheet and report has consequently been unavoidably delayed, but it is hoped that both may be ready in time to form a part of the next Annual Volume of the Geological Survey.

Mr. James McEvoy left Ottawa on the 20th of June for field work in the interior of British Columbia, and returned on the 6th of November.

He reports as follows on the special work entrusted to him, as above explained :—

The season was chiefly spent in continuing the work within the area of the Shuswap sheet of the geological map. This sheet is referred

to in the report of Dr. G. M. Dawson's work in the Summary Report for 1890. It embraces the country immediately to the east of that covered by the Kamloops sheet and like it is laid out with sides eighty miles in length, thus covering an area of 6,400 square miles.

The first ten days of the season were occupied by a short trip into the northern part of the area covered by the Kamloops sheet to secure some additional information of the country between Loon lake and Deadman river, necessary for the completion of that sheet. While in this vicinity a number of specimens of the hyalite discovered in 1889 were collected.

After the completion of this trip the country between Chapron lake and Okanagan lake was visited. As there were no trails progress was necessarily slow ; two traverses were, however, made across it, besides several shorter ones, and three mountain summits were occupied for topographical sketches. Here, and generally throughout the western and southern portions of the area of the Shuswap sheet, the Tertiary volcanic rocks are more extensively developed than was formerly supposed. At a rough estimate they cover about a-fourth of the whole area of the sheet.

During the season Shuswap, Long, Mabel and Sugar lakes and a part of Okanagan lake were surveyed with a patent floating log and prismatic compass. Observations for latitude were taken with a seven-inch sextant to fix places not otherwise determined.

Neither Mabel nor Sugar lakes had ever been surveyed and were only very roughly indicated on existing maps. They are situated in the foot-hills of the Gold range on the Shuswap river and are about 35 miles apart by the river route. Their shores are rocky, being composed of gneiss and mica-schists of the Shuswap series, with large masses of pegmatite and graphic granite included. At the head of Sugar lake grey granite replaces the gneiss entirely, holding in many places angular fragments of mica-schist.

To the north-east of Enderby, and south of the Canadian Pacific railway, the mountains were ascended and two transit stations were established at an elevation of more than 6,000 feet. These mountains are almost bare of trees, and, where not too rugged, travelling is easy. Bear, caribou and deer are abundant.

Another transit station was made on the mountains north-east of Sugar lake on the eastern boundary of the sheet. These and several compass stations on either side of White valley, together with the points occupied in 1890, will afford sufficient data for the construction of an approximately accurate topographical map.

Southward and easterly from Salmon Arm, along Canoe creek and Deep creek, there is an extensive area of flat land, with grey silty soil, very suitable for farming. Generally this area is lightly timbered, while much of it having been burnt over would be easily cleared for cultivation.

About half way between Lansdowne, on the Shuswap and Okanagan railway, and the first crossing of the Salmon river by the waggon road to Grande Prairie, specimens of garnet were discovered. The crystals are nearly equal in size to the Stikine garnets and are enclosed in a light grey mica-schist and in places form at least half of the rock mass.

Though not included within the area of the Shuswap sheet, it may be mentioned that the numerous discoveries of silver-bearing galena and zinc blende on the North Thompson river at Mosquito Flat and above the Clearwater, are attracting a good deal of attention. These localities are situated about 50 miles and 75 miles respectively from Kamloops. The ores are said to give rich assays.

The following specimens from Mosquito Flat were assayed in the laboratory of this Department :—

1. Zinc blende with a little galena : gold, none ; silver, 11·666 ounces per ton.
2. Galena and zinc blende in quartz : gold, none ; silver, 48·125 ounces per ton.

During the season 330 miles of patent log surveys and 540 miles of track surveys were made.

Mr. McEvoy was assisted by Mr. J. McGregor, B.A.

The total cost of the exploration was \$1,459.73.

Mr. R. G. McConnell obtained leave of absence last summer for the purpose of visiting the European Alps and studying their structure as an aid to further work in the Rocky Mountains of Canada, and the field work done by him last summer was limited to an examination of part of the Bow River valley, in Alberta.

Mr. McConnell supplies the following statement respecting this examination: "This work was carried out during the month of June and was undertaken with a view of ascertaining whether the coal-bearing Cretaceous rocks of the Cascade basin recur east of the mountains. The section along the Bow proved to be too complicated and was intercepted by too many concealed intervals to trace the sequence of the formations definitely throughout, but sufficient evidence was collected to show that in all probability the conglomeritic beds exposed at the Kananaskis Falls are the equivalents of those overlying Marsh's

mine, south of the Gap siding in the Cascade basin, and that the underlying dark shales consequently represent the coal-bearing formation. East of the mouth of the Kananaskis the conglomerates and underlying shales fold over a light anticlinal, and several hundred feet of the latter are exposed without any coal seams being seen. The summit of this anticlinal, which occurs three-quarters of a mile east of the mouth of the Kananaskis river, offers the most favourable site for testing by means of a bore hole for the presence of coal. The coal horizon of Marsh's mine, assuming the identification of the conglomerates to be correct, lies at this point at a depth of 1,300 feet below the surface. There is, however, no absolute certainty that even if this depth was reached coal would be obtained, owing to the lack of persistence of the Cretaceous coal seams, and on the other hand workable seams might be struck at a much less depth. The rocks near the mouth of the Kananaskis river are comparatively undisturbed, and coal, if present, would be much less crushed and also more easily worked than is the case with many of the seams enclosed between the more highly inclined beds of the Cascade basin, and on this account a bore hole to test its presence would be desirable.

"In returning east I descended the Bow in a boat as far as Gleichen, for the purpose of studying the mode of junction between the eastern and western drift, and on the way collected a number of interesting facts bearing on this subject which will be published later on. Cost of exploration, \$324.85."

During the past summer Mr. J. B. Tyrrell, and Mr. D. B. Dowling, with Mr. J. C. Gwillim as assistant, completed the geological examination and mapping of Lake Winnipeg, and made reconnaissance surveys of many of the streams flowing into both the eastern and western sides of this extensive body of water. Mr. Tyrrell reports as follows: "The two small sail-boats that had been stored at Selkirk at the end of the season 1890 were repainted and again placed in the water. Supplies for a month were procured from Capt. Wm. Robinson, and arrangements were made with him to have provisions shipped from time to time to various places around Lake Winnipeg, where they could be obtained, in passing, without unnecessary delay. Two canoes had been ordered from Peterboro' for the examination of the streams flowing into the lake, but they did not arrive till later in the summer.

"On the 5th of July, after having been delayed in Selkirk for several days by wet and stormy weather, we started northward in tow of the steamer *Sultana*, and early on the morning of the following day

reached the harbour at Swampy island, whence we sailed eastward to the mouth of Beren's river.

"Having determined to divide the party in order to accomplish a wider range of exploration during the season, Mr. Dowling was sent northward with the larger sail-boat to examine St. George and Sandy islands, to take levels on the Saskatchewan river, to follow the west shore of the lake from Limestone bay southward to the mouth of Red river, and to explore the streams emptying into that side of the lake. This work he has successfully performed, as is shown by his report appended hereto.

"From Beren's river I turned southward and devoted the summer to a close examination of the eastern shore of the lake up to the mouth of Red river, and an exploration and survey of the principal streams discharging into that portion of the lake lying north of the straits at Dog Head, including Loon, Wepiscow, Wanipigow, Manigotagan, Sand, Black, Winnipeg and Brokenhead rivers, and thus it has been possible to outline with some degree of accuracy the extent of country underlain respectively by comparatively barren granites and gneisses and by Keewatin schists and quartzites which might be profitably examined for the presence of the ores of the richer metals.

"The investigations of Mr. Low, in 1886, had shown that Beren's river, throughout the whole of the course followed on his journey to Hudson's bay, flowed through country composed of Laurentian granites and gneisses, and from the mouth of this river up to Dog Head straits the shore of Lake Winnipeg is composed of similar rocks. At this latter point these gneisses begin to assume a very regularly banded arrangement parallel to the lake, and a few miles further south dykes of dark green trap begin to make their appearance, running in the same direction. Then irruptive rocks continue close to the east shore as far south as Wanipigow or Hole river, where they merge into an extensive area of eruptive volcanic rocks and agglomerates that form the base of the Keewatin series. On ascending the streams that flow into this portion of the lake, namely, the Loon, and Wepiscow or Rice rivers, the gneiss is seen to be very regularly and evenly banded near the eruptive rocks, while further east it changes imperceptibly into the coarse grey irregularly foliated Laurentian gneiss typical of that whole region. Punk island and the many small islands between it and Black island and the main shore were examined, and while the former at its eastern end was found to be composed chiefly of St. Peter's sandstone, the latter consists of altered conglomerates quartzose sandstones, agglomerates, chloritic and sericitic schists, &c., similar to those found in the typical Keewatin in the Huronian districts elsewhere. The

quartzites and conglomerates are somewhat more easily eroded than the adjoining volcanic rocks, and they therefore lie in a hollow which is flanked on one side by Black island, and on the other by the west shore, the beds standing generally at a high angle and striking parallel to the general curving trend of the shore.

" After these islands had been examined, Wanipigow or Hole river was ascended to the lake; a survey was made of the lake, and the river was also examined and surveyed to the first heavy rapid above the lake, beyond which we were unable to proceed on account of the lowness of the water. At its mouth the river breaks through a belt of evenly banded gneisses, above which it flows for ten or twelve miles through a rich alluvial plain wooded with poplar and white spruce, the banks on either side rising to a height of from fifteen to twenty feet above the water. Very little rock is to be seen, but any exposures that do outcrop from beneath the till and alluvial deposits consist of massive coarse amphibolites and green chloritic schists. On Wanipigow lake the rocks are also almost entirely of the same character, though on some places on the north shore the gneiss approaches close to the water, and the contact of the green Keewatin schists and the Laurentian gneiss is well shown. Speaking generally, the lake and valley of the river lie in a trough of Keewatin schists, the north side of which is bounded by ridges of Laurentian granites and gneisses, while the south side rises in hills of more compact green schist the contact of which with the Laurentian was not here observed.

" A stream called English river, a tributary of Wanipigow river, and the lake into which it expands in the middle of its course, were likewise surveyed. This river in its lower portion also flows over Keewatin schists, but the lowest rapid occurs at the contact of the schist and gneisses, and above this its course is through rugged country composed of high barren hills of grey gneiss thinly wooded with a stunted growth of small Banksian pine. Specimens of galena and chalcopyrite, stated to have been found on the north shore of Wanipigow Lake, were shown to the writer, and the occurrence of these minerals is not improbable along the above-mentioned contact line.

" From the mouth of the Wanipigow river to Manigotagan or Badthroat bay the shore is composed of greenish grey evenly banded gneisses with schists and altered traps of the Keewatin series, while near Clement point these are overlain by St. Peter sand-stone (Chazy,) this being the most northerly point at which Palæozoic rocks have been recognized on the east side of the lake.

" Manigotagan or Badthroat river was then ascended to Rat Portage lake, a track survey was made of this lake, and the river was

ascended for a short distance above it. The river is remarkably picturesque throughout, consisting of long quiet stretches of clear brown water, separated by rocky rapids or high abrupt falls which are passed on portages of an average length of from one to two hundred yards, twenty-three of which must be ascended on the way from Lake Winnipeg to Rat Portage lake.

"At the mouth of the river and up to the second portage, the rock is a thin and evenly banded hornblende schist, while throughout the rest of the distance to the latter lake it consists entirely of Laurentian granites and gneisses, rising in places in hills of from one to two hundred feet in height, the summits of which present a wintry bareness throughout the year.

"From the mouth of Manigotagan river to Pt. Metasse, north of the mouth of Winnipeg river, granites and gneisses everywhere compose the points on the shore, and these points are usually connected by gently curved sandy beaches in front of low-lying alluvial land.

"Sand river was ascended through this alluvial plain to the first rapid where it was found to be too small for further ascent with our large Peterborough canoe, but the rock, where seen, was similar to that on the shore.

"Black river was also ascended past thirty-three portages to a point south of Rat Portage lake, where a portage a mile and a-half in length strikes off to the northward. The stream is shallow and much obstructed by boulders and sandbars throughout, and the rocks on either side are everywhere Laurentian granites and gneisses.

"Winnipeg river was ascended to the mouth of the Whitemouth, and on the return a track survey was made of Lac du Bonnet.

"The rocks on the main stream are all granites and gneisses, but towards the east end of Lac du Bonnet, and around the mouth of L'Oiseau river, thin-bedded green schists and altered traps, doubtless of Keewatin age, make their appearance, striking up the valley of the latter stream.

"Above Lac du Bonnet the banks of the river, as far as examined, were chiefly composed of till, with many limestone boulders, and the rocks are scored in a S. S. E.'ly as well as in a S. W.'ly direction, showing that the earlier glacier moving south-eastward over the Palæozoic Lake Winnipeg basin had extended at least this far eastward, though there is no sign of limestone drift on the main portion of Lac du Bonnet itself or on the lower part of Winnipeg river.

"From the mouth of Winnipeg river the shore of Lake Winnipeg was explored to the mouth of Red river, and a short trip was made

up the Brokenhead river to the first rapid. A paced survey was also made of Elk island, and excellent sections of St. Peter's sandstone were found, both on this island and on the long point of land opposite. In this vicinity were also found many interesting sections of the drift deposits, some of which show the alluvial clay of the east shore of the lake interbedded with glacial till, proving clearly that this clay was deposited close to the oscillating front of the glacier descending from the highlands to the east.

"As the stormy autumn weather had now set in, the boats and supplies were stored with Capt. Wm. Robinson at West Selkirk, and Lake Winnipeg was left for the season. On the way east a short time was spent at Bird's Hill to examine the remarkable ridge of gravel that there rises through the surrounding hard boulder-clay, and again at East Selkirk to see the section of Trenton limestone exposed there in a quarry north of the railway. The exposure is an interesting one, as it shows a hill of limestone, the top of which has been broken up and shoved along by the glacier of the Winnipeg basin, leaving what is known as a *tail* deposit of loose material behind a protecting *crag*. It is chiefly from this broken *tail* material that the blocks of limestone used in Winnipeg for building purposes are quarried.

"I also remained for two days at Sudbury for the purpose of comparing the rocks that are there so rich in copper and nickel with those found on the east side of Lake Winnipeg, and it was very gratifying to see the remarkably close similarity between the two sets of rocks.

"During the season forty-four large and eighty-eight small photographs were taken of characteristic sections and surfaces of rock, and of particularly interesting features of the landscape.

"The following is Mr. Dowling's account of the work accomplished by him during the summer:—

'I left Beren's river on the 8th of July, after having secured the services of a competent sailor. Our first halt was at George's island, where I made a paced survey of its shores. We then called at Little George's and the Sandy island. After stopping at Poplar Point to take observations, our next halt was at Selkirk island, the shores of which were examined, and a traverse made with compass and boat log. There are here several small exposures of a hard mottled dolomitic limestone, somewhat similar to that on the mainland west of this island. We went from here to the Grand Rapids, where I levelled across to the head of the tramway with the transit, making a section on the tramway. This road is about three miles and a half long, and rises at its highest point to 128 feet above the lake, having a total rise of 71 feet between its upper and its lower end.'

'Four well-marked lake beaches are crossed at elevations of 78, 91, 95 and 118 feet above present lake level. The lower one was followed about two miles north, and its crest was found to vary in elevation from 78 to 80 feet. With an Indian and his canoe we ascended the Saskatchewan and crossed Cedar lake to the "Mossy portage," an old portage road between Cedar lake and Lake Winnipegosis, to determine the heights of several gravel ridges. The difference in the level of the two lakes was then only nine inches, Lake Winnipegosis being the higher. After returning, a trip was made along the west shore towards Limestone bay with a Peterborough canoe that had just arrived. From Grand rapids I sent the sail-boat to Reindeer island and with the canoe went along the shore south to near Clark's point, crossed over to St. Martin islands and thence north joining the boat at Reindeer harbour. We then sailed along the west shore to Little Saskatchewan, where the boat was left for another canoe trip. We went up the Little Saskatchewan river, to the elbow, portaged over to the South Branch of the War Path river and descended this stream to its mouth; at the time of our trip this stream was very shallow and we found it slow work getting down. The country through which it runs is sloping gently to the north-east and is wooded principally with poplar and tamarack and a few spruce. From the mouth of the Little Saskatchewan we ran along the shore with the large boat and examined the cliffs of yellow dolomite west from Cat Head.

'From Kinnow bay to Fisher river the shore is rather low, the land behind being very little above the lake, with the exception of a few ridges of drift material that seem to trend in a north and south direction and where extending into the lake form boulder bars and boulder-strewn points.

'At Fisher river there is a large Indian reserve having good farming land a short distance from the mouth of the river, the lower part near the lake being all splendid hay flats. The Indians seem to be very comfortable and have several good fields of grain and many fine looking cattle. The river for about twenty miles is a sluggish stream with a few shallow parts with some current. The greatest fall is at the Big Rapids and is about four feet, but in the whole length of the river to The Forks there is only about twenty feet fall. The country passed through is quite level, wooded for the most part with poplar; but a considerable portion has been fire-killed and almost reduced to prairie. Between the patches of timber open hay land was seen and swamps are reported rare, so this should make excellent land for settlement.

'From Dog Head to Bull Head the exposures are of Trenton limestone and were examined and measured. From Bull Head to Big island the underlying St. Peter's sandstone is frequently exposed in the same cliff with the limestone. The east side of Big island is seen to be underlain by limestone which is exposed in sections of from 10 to 20 feet extending from the north end to about the middle of the island. The southern part is covered principally with drift material causing the shore at its southern extremity to be boulder strewn and the water shallow. On the 29th of September I returned to Selkirk and stored the outfit; leaving the boat in the care of Mr. Muckle, Indian agent at Clandeboye.

'I was about starting for Ottawa when Mr. Tyrrell returned from the lake and commissioned me to examine the rock exposures at Stonewall, Stony mountain and lower Fort Garry. At Stonewall I observed two sets of glacial grooves on the surface of the rock, the striæ running S. 25° E. and S. 10° W., the latter evidently the newer.

'The present season's work enables us to complete the section of the Cambro-Silurian formations, which rest unconformably on the Archæan rocks of the east side of Lake Winnipeg and seem to underlie conformably the Silurian which was observed at Grand rapids by Mr. Tyrrell.'

'Typical examples of the lower division consisting of beds of friable sandstone and shales may be seen at Grindstone point and Deer island.

'The middle division is represented by mottled yellow limestones at Selkirk, Dog Head and Beren's island, while the upper division consists of impure limestones and shales as at Stony mountain and Clark's point, Lake Winnipeg.'

'About forty photographs of the various rock exposures were taken. Mr. Dowling left for Ottawa on the 11th of October.'

"Cost of season's exploration \$2,059.29."

Mr. McInnes left Ottawa on the 17th of July, with instructions to continue the work of 1890 in western Ontario, between the Lake of the Woods and Thunder bay, Lake Superior, and arrived at Port Arthur on the 20th. Provisions and men were obtained there for the season's work, and Mr. Chas. Marks, of Port Arthur, was engaged as assistant for the season. Mr. McInnes reports as follows:—

"On the 25th a start was made southward from Savanne by canoes, and the interval between this date and the 16th of August was spent in an examination of the country lying on either side of Kashabowie lake

"The streams flowing into the lake were first ascended and the lakes along their course were surveyed by prismatic compass and boat log. A survey of the same character was made of Trout lake, which lies to the east of the north end of Kashabowie lake.

"The main body of this lake, which is about six miles in length and a mile and a-half in width, lies entirely within the gneiss area which occupies the greater part of the shores of Lac des Mille Lacs. This gneiss was found to extend continuously northward from Troutlake and to occupy the whole of the country northward to the Savanne river and the Canadian Pacific railway track. The country about the height of land here is an immense swamp which divides the water of Lake Superior and Lake Winnipeg, sparsely wooded with tamarack and stunted spruce, and with here and there low ridges of granitoid gneiss rising from the general level.

"After completing the survey of Trout lake, Asagesh or Crayfish river was next ascended, and a track survey made of it and a log survey of the lakes along its course. About a week was spent in surveying the lakes at the heads of its two branches and in fixing the southern limit of the Kashabowie belt of gneiss, at different points in the neighbourhood. The country about Round and Jackfish lakes was next visited, and a week was spent in tracing geological boundaries in that district. At the Huronian mine which has not been worked since 1885, the buildings, ten-stamp mill and vanners, &c., boarding house, shaft house, store houses, &c., were found in a good state of repair; the shaft was however filled with water and the vein could be seen only in the extension to the south-west at the Highland mine opening, where it is clearly defined and highly mineralized with iron and copper pyrites. There seems good reason to hope that with possible future railway extension in that direction, and the consequent improvement in means of transport, the properties on this vein may be profitably worked.

"Returning to Lake Shebandowan a survey was made of a series of lakes and streams extending northward to a point near the Canadian Pacific railway at Nordland station. The granite-gneiss was found to extend from a point near the Muskeg river which enters Lake Shebandowan from the north near its outlet northward to the railroad track, the belt of Keewatin rocks which has a considerable width on Lac des Mille Lacs having given place to the gneisses a short distance to the east of the lake.

"The remainder of the canoeing season was occupied in an exploration of the country lying to the south of Lake Shebandowan. A canoe route was followed leading southwards to Keekukuab river, a branch

of the Mattawin, and returning by a chain of small lakes leading across to Greenwater lake. With the exception of one small lens-shaped area of gneiss which lies about three miles to the south of Lake Shebandowan, Keewatin diorites and schists were found to extend over the whole area southward, as far as Kekekuab lake, where the northern edge of the broad belt of gneiss of Northern Light and Seignanagah lakes is struck. A number of bands, 20 feet or thereabout in width, of magnetite interstratified with schistose layers of hornblende, quartz, &c., were noticed in the dioritic areas of the Keewatin in this district. The magnetite occurs in narrow bands a quarter of an inch in thickness with thin layers of about the same thickness of the schistose material interstratified, the whole often highly contorted and twisted locally, though preserving a general trend parallel with the enclosing diorites and schists. Specimens of this ore collected from near the eastern side of Greenwater lake were submitted to Mr. Hoffmann, the chemist of the department, who describes it as 'a very fine grained, almost compact, schistose magnetite from Greenwater lake, district of Thunder Bay, Ont.,—collected by Mr. McInnes, 4th October, 1891,—has been examined by Mr. F. G. Wait, and found to contain :

Metallic iron.....	52·82 per cent.
Insoluble matter	22·31 do
Titanic acid.....	none

a good iron ore.'

"This, it will be seen, is a most encouraging report, both in the high percentage of metallic iron and in the absence of titanic acid, and gives good reason for the hope that a thorough exploration of the region will reveal valuable deposits of this ore. A number of locations have already been taken up in the vicinity of the Mattawin river and during the past summer considerable work was done towards testing some of these properties, the result of which has not however been learned.

"In the district further west very commendable enterprise has been shown by the Marks Company in thoroughly testing their iron properties on the Atikokan by the diamond drill. It is stated that the results have been satisfactory. Mr. Smith who makes a separate report will deal with this region in detail.

"In the whole region explored during the summer, the areas of land adapted for cultivation are few and very limited in extent. As pasture much of it might be greatly improved. This is well shown by the luxuriant growth of red and white clover and timothy grass where seed had been scattered around the old construction camps along the line of the Canadian Pacific railway. But doubtless the future of the district will depend largely upon its contained minerals and it is

to be hoped that the present very promising discoveries of extensive deposits of iron ore may be found to warrant the building of the necessary works for smelting the ores somewhere in the neighbourhood."

Mr. McInnes returned to Ottawa on the 30th of October.

The total cost of the season's explorations was \$994.71.

Mr. Smith left Ottawa on the 16th of June, and was joined in Toronto by his assistant, Mr. William Lawson, whence they proceeded at once to Port Arthur.

After securing men and purchasing supplies, Mr. Lawson left English river on the 25th of June to make a compass and log survey of the chain of lakes running southwesterly from there, which it was thought might be partly within the area of the Seine river sheet. On the completion of this survey as far as the north-eastern arm of Turtle or Crow Rock lake, he travelled to Fort Frances.

Mr. Smith went through the chain of lakes and streams comprising a hitherto unknown route from Ignace to the headwaters of the Big Turtle river. He passed down this river, surveying on the way Pekagoning lake, which encroached on the northern limit of the Seine river sheet ; and from thence he proceeded to Fort Frances to rejoin Mr. Lawson and obtain supplies.

The united parties left Fort Frances on the 18th of July and ascended by the Manitou canoe route to the northern limit of the area included in the Rainy lake sheet, No. 3, already published. Work was commenced here, in accordance with instructions, on the area to be included in the sheet No. 4, north of No. 3. A micrometer and compass survey of the east side of Manitou lake was made, also of a smaller lake to the west of it ; and the survey commenced in 1885 of the smaller lakes on this route, between Manitou and Little Wabigoon lakes, was completed.

From Wabigoon Messrs. Smith and Lawson surveyed a route to the headwaters of the Big Turtle river, securing another tie line connecting the surveys of 1890 with the line of the Canadian Pacific railway. From the headwaters of the Big Turtle river Mr. Smith proceeded to Martin lake to verify the existence of a band of Keewatin schists supposed to occur south of this lake ; this supposition was proved to be correct. Mr. Lawson at the same time examined some small lakes shown on the timber limit surveys in the vicinity of Clear and Clearwater lakes. On their reunion they proceeded to English river.

After obtaining more supplies, they endeavoured to discover a route south-westerly from English river to the Seine river, but failed to get

more than 16 miles. Then the party descended by the route traversed by Mr. Lawson in July, from the English river to Long lake, where the party again separated, Mr. Smith pushing through a hitherto unknown route to the Seine river, which resulted in the addition of six small lakes to the topography of the Seine river sheet.

Thence he proceeded to Steep Rock lake to rejoin Mr. Lawson who had descended by the Eye river to the Seine river, and thence up it to Steep Rock lake, making some geological observations needed to complete the work of 1890.

In Steep Rock lake five days were employed in investigating an apparently unconformable series of rocks found here, and which it is hoped will afford a further clue to the elucidation of the Archæan structural geology of the district.

From Steep Rock lake Mr. Smith ascended the Atikokan river to mining locations R. 400 and R. 401 where three days were spent in obtaining a section of the iron-bearing rocks, the relative age of which is not yet determined, and in examining the iron ore deposits of these locations. From here he proceeded to Savanne, arriving there on the 1st of October.

From Steep Rock lake Mr. Lawson descended the Seine river and crossed into Beaver lake which he surveyed, and after obtaining a section from Steep Rock lake to Clearwater lake he proceeded to Savanne, where he arrived on the 3rd of October, and closed the season's work.

The topography of the Seine river sheet is now complete, several lakes unknown last season having been added, but the geological problems involved in this area are so important that a few weeks more will be required to further investigate them. A brief sketch of the geology of this field was given in the Summary Report for 1890, p. 28.

Mr. Smith discovered excellent indications of a broad zone of magnetic iron ore, on the west side of a lake on the Big Turtle river called "The Lake where the River Bends." The ore is associated and interbanded with micaceous schists. The bands vary from fractions of an inch to three feet or more in thickness, and this interbanded occurrence of ore and schist in its broadest development appears to be from 150 to 200 feet wide. To the south-east near the southern end of the lake this band appears to be cut off by a fault and from this fault northward the iron ore could not be traced for more than a mile and a-half, the rocks being so thickly covered with vegetable mould that exploration in this direction was difficult and uncertain. The rocks here strike north-west and south-east and dip from 45° to 55° to the south-west. They are very evenly stratiform in appearance and seem

to constitute a tapering band trending eastward, then south-eastward, from the broad band of Keewatin schists so largely developed in Manitou and Little Wabigoon lakes, and from certain ferruginous angular fragments found in the north-eastern arm of Manitou lake, Mr. Smith is inclined to think that more ores may be found in this vicinity, in the same geological horizon as the above, in the near neighbourhood of the granites.

An analysis of these ores made by Mr. G. C. Hoffmann, chemist to this department, shows them to be very siliceous, yielding 40·17 per cent metallic iron and 37·21 per cent of insoluble matter, but no titanic acid.

The locality is about 19 miles south-west by south of Raleigh station on the Canadian Pacific railway. It could be reached by about 21 miles of railway through a comparatively level country. It would be possible, with light expense involved in building short tramways, to carry light ore trucks over the portages, four in number and aggregating one mile and a-half in length, to reach the Canadian Pacific railway by 40 miles of navigable water-way *via* Snake lake and Snake and Wabigoon rivers.

The ore is in such a position as to be easily mined, and considerable water power is afforded at the outlet and inlet of the Big Turtle river. Unless the ore is found, as usual in this country, to be much richer in the actual ore bodies than in the surface indications, it will, of course, be of no commercial value in competition with the rich ores of the Lake Superior district on both sides of the international boundary.

The gold locations on the lake west of Manitou lake were visited during the summer and some specimens from the veins collected. The field appearance is very encouraging. One vein in particular seems to be a very strong one and in some places is as wide as ten feet of promising looking quartz associated with soft soapy talc schist in soft chlorite schist.

The iron ores of the Atikokan river have in two locations been carefully tested this summer with very gratifying results, but the details of the diamond drill borings are not yet made public. On the completion of the Atikokan Iron Range railway it is hoped actual mining will be engaged in here. The ores are very rich and pure, running as high as 60 and 70 per cent of metallic iron.

Very little prospecting has been done in the Thunder bay and Rainy river districts this summer, said to be the result of the change in the Ontario mining laws.

The season's work was mainly geological in character, but some 150 miles of compass and micrometer lines, 100 miles of log and compass

lines, and 50 miles of time traverse were run, serving as bases for the compass triangulation of islands and intermediate points.

Mr. Smith returned to Ottawa on the 10th of October.

Cost of exploration, including salary of assistant, \$1,234.

Dr. Bell was requested to complete during the summer, if possible, the geological survey of the area embraced in sheet 125 of the Ontario series which adjoins the Sudbury district sheet on the south. Mr. A. E. Barlow, M.A., was to assist Dr. Bell as during the four preceding years. With the approval of the Minister, the party was to include the following gentlemen : Messrs. A. M. Campbell, H. H. Walker, B.A.Sc., H. G. Skill, A. C. Robertson, W. G. Miller, B.A., and R. W. Brock. Mr. Barlow left Ottawa for the field on the 10th of July, and returned to this city on the 1st of October. Dr. Bell left on the 23rd of July, and returned on the 6th of October.

On the work of the party Dr. Bell reports as follows :—

“ Mr. Barlow worked principally in the north-western part of the sheet, in the neighbourhood of Lake Panache, and between Collin's inlet, and the lower part of the Wahnapitae river. He also visited some localities in the Sudbury district, near the line of the Canadian Pacific railway, for the purpose of obtaining mineral specimens. The details of his work are given in his own words herewith : ‘ I have to express my entire satisfaction with the manner in which all the above-named gentlemen performed the duties allotted to them.

“ The central and southern part of sheet 125, amounting to about one-half its area, is occupied by the waters of Georgian bay, while many channels and inland lakes diminish considerably the area of dry land in the remaining half.

“ The north-east corner of the sheet is at the western extremity of Lake Nipissing, the north-west in the township of Hallam, the south-east in that of Shawenaga, while the south-west is near the south-eastern extremity of Grand Manitoulin island. Most of the topography of the sheet could have been represented pretty well by compiling the hydrographic surveys of Commander Boulton, R.N., the river and lake surveys of the late Mr. Murray, of the Geological Survey, and the lines run for the subdivision of the land by the Crown Lands Department. Still some parts were either entirely unsurveyed, or were too poorly defined for our purposes, and we were obliged to survey them ourselves.’ The portions executed by Mr. Barlow are described by himself in the statement above referred to.

"My own topographical work embraced the following: A micrometer and compass survey of the shores and islands of the large bay between Great Cloche island and the north shore of Lake Huron. The islands in this bay are exceedingly numerous, amounting probably to a thousand or more, and as the bay has heretofore been without a name, I called it Bay of Islands, with the approval of Captain Boulton and the inhabitants and lumbermen of the neighbourhood. Cloche channel and peninsula, and the peninsula between Bay of Islands and McGregor bay were next surveyed in the same manner, and finally the latter bay, including a very large number of islands, and also the channels in its northern part, and those lying still further north. This work was begun on the 28th of July, and completed on the 29th of August. In its performance I was assisted by Messrs. Miller and Brock.

"Track surveys were made of a lake five miles in length in the interior of Great Cloche island, and of the five principal lakes lying between Killarney bay and the Mazinwozine river, which discharges into Collin's inlet, namely, George, Trout, Sturgeon, Ka-ko-kis and West lakes with their connecting streams. A number of smaller lakes in this district were also located. In this work I was assisted by Mr. H. G. Skill and Mr. Myles Tyson, the latter of whom had a good knowledge of the local topography which proved of much service in economising our time. Being favoured with very fine weather we were enabled to accomplish this part of the work between the 5th and the 11th of September.

"On the 13th of September we proceeded by steamer from Killarney to the French river region in order to add to the geological information which had been already obtained there by the late Mr. Alexander Murray and myself and to survey and locate some topographical features not previously indicated upon any map. Careful track-surveys were made of a long narrow channel running north-westward from the expansion of the river where the North Channel West is joined by the South Channel East; of a canoe-route from the head of this channel to Trout lake, of this lake itself (which is twelve miles long) and of a canoe-route by way of Ka-was-ki-gama, or Crooked lake, to the rocky delta of the middle group of outlets of French river. Numerous minor additions were likewise made to our knowledge of the topography of this region and also some corrections of the topography already laid down upon the maps.

"The part of Grand Manitoulin island which comes within the sheet, and consists principally of its eastern peninsula, had been examined by myself in 1859, 1865, 1876 and 1886 and the boundaries of the various formations traced out and represented upon the geological

maps; but for the sake of attaining greater accuracy in some localities I sent Mr. Miller with three men to go over part of the ground during the first half of September, and my own time and that of Mr. Miller and Mr. Brock for the last week of the season was devoted to the same work, so that the geological lines in this part of the sheet can now be represented in accurate detail. Mr. Skill was employed from the 19th of September to the end of that month in tracing the details of the boundary between the Laurentian and Huronian rocks, from Killarney bay north-eastward to the lakes we had surveyed behind Collin's inlet.

"In regard to the geology of the sheet, we were enabled to fill in all that was required to complete it for publication. The area of dry land is only about half that represented upon the Sudbury sheet and the distribution of the rock-formations was more easily worked out than upon the latter, as the region was more accessible and as the greater part of its area consists of Laurentian gneiss and nearly horizontal Silurian formations. We had also the advantage of the previous geological work of Mr. Murray and myself in the district. Besides these two systems the Huronian is represented by a small area in the north-western corner of the sheet.

"The Laurentian rocks which come within the sheet probably belong to the upper division of the system and consist of grey and red gneisses, generally in distinct beds, which run comparatively straight for considerable distances. The grey varieties are generally coarser than the red and their foliation is often indicated by the parallelism of the larger diameters of the grains rather than by distinct bedding or bands of colour, although these are also often present. But both the grey and red varieties become schistose in many places, and they sometimes enclose regular belts of hornblende and mica-schists, the latter always holding garnets.

"On the coast of Georgian bay, from the township of Carlyle to the eastern mouth of French river, the strike is uniformly to the north-eastward and the dip generally to the south-eastward at tolerably high angles, but in the central part of the course of French river it is mostly north-westward and westward, but with many local variations. From the eastern mouth of French river to Shawenaga bay the strike varies from north-west to south-west.

"The boundary line between the Laurentian and Huronian leaves the head of Killarney bay and runs north-eastward with a curve to the south-east and reaches the northern edge of the sheet in township 68 a short distance east of Lake Panache. From this line south-eastward as far as Collin's inlet, the rock is massive or shows only slight or local foliation and most of it might be called red hornblende-granite. A

similar rock, described by Mr. Murray as (quartz) syenite, occurs for a breadth of two miles between the Western and Middle mouths of French river.

"The Huronian rocks of the north-west corner of the sheet consist principally of quartzite, but greenstones sometimes occur among them, and they are occasionally interstratified with greywackes, clay slates, crystalline schists and other rocks in smaller quantities. Among the latter is the band of dolomite described in my report for 1876, page 209. The greenstones form a much less prominent feature among the quartzites and greywackes than further inland. They consist of several narrow belts in the neighbourhood of Lake Panache and among the islands near the north shore of Lake Huron, where they are traceable for from one mile to three, and correspond in most cases with the general direction of the strike. Much smaller masses of greenstone of various forms and lying at every angle with the strike are enclosed among the quartzites in all parts of their distribution within the sheet. Along the contact between the two systems the granite and the quartzite are a good deal intermingled; large isolated pieces of the one being incorporated in the other.

"The quartzites form the La Cloche mountains and the long and high points jutting south-westward into Lake Huron between McGregor and Killarney bays, as well as Badgeley, Centre and Heyword islands. Our surveys appear to confirm my previous opinion that the several belts of quartzite forming the La Cloche mountains are repeated in these high points and islands which represent the opposite side of a syncline or possibly an anticline.

"In the La Cloche mountains, which rise from 400 to 750 feet above Lake Huron, and also around Bay of Islands and McGregor, the strike is nearly east and west with high or almost vertical dips, mostly to the north; but further south it follows the axes of the points and islands just mentioned.

"A belt of sericite schist was traced on the north sides of Bay of Islands and of McGregor bay and on the isthmus between them and another belt of the same rock through the islands of these bays at a distance of a mile and a quarter south of the first. The greenstones above referred to were found principally towards the south side of Bay of Islands, but in the area covered by McGregor bay and in the channels to the north of it they occur in various parts, but are most abundant in the central and western portions. Clay slates were found in some abundance in the northern part of the township of McKinnon.

"The rocks of the whole district covered by the sheet have been everywhere glaciated. A number of photographs illustrating glacial

action were obtained and much interesting information was collected in reference to the phenomena of the drift."

Expended on field work by Dr. Bell, \$950, by Mr. Barlow, \$1,080.

Dr. Ells left Ottawa for field work on the 8th of June with instructions to complete the revision of the geological boundaries as laid down on the Montreal or south-west quarter sheet of the map of the Eastern Townships and then to continue the work westwards up the valley of the Ottawa and its northern tributaries. In carrying out the first part of this work which was completed on the 20th June, Dr. Ells reports that a "number of fossils were collected by Mr. W. E. Deeks, B.A., from places on the Calciferous, Chazy, Trenton and Hudson River formations, where fossils had not previously been collected by the officers of the survey. On the 22nd of June Dr. Ells, accompanied by Mr. F. D. Adams, of McGill College, started from Grenville for Iroquois Chute on the River Rouge near Trembling lake, with a view to re-examine the character and relations of the limestone and gneiss bands of the Trembling lake and mountain, and also to trace out the western boundary of the great anorthosite area of Wolfe and Grandison.

"The country around Trembling lake was examined, then the Macaza river was ascended to its head, thence crossing to a lake on the west branch of the Devil's river. This lake is not laid down on the Provinces map, and of which we made a track survey from Devil's to its junction with the outlet of Trembling lake, there fixing the western limit of the anorthosite in this direction.

"The first part of the season to the 20th of June, was spent in the examination of the country to the south and south-west of Montreal, necessary for the completion of the south-west quarter-sheet of the Eastern Township map. Valuable collections of fossils were made from the Calciferous, Chazy, Trenton and Hudson River formations by Mr. W. E. Deeks, B.A., many of which are from places not previously examined by the officers of the survey. A very large portion of this area is covered by a deep deposit of drift, and rock outcrops are, as a consequence, rarely seen. The geological boundaries laid down on the map of 1866 were carefully followed, in so far as the drift would permit, but in such an area these must of necessity be largely conjectural.

"Accompanied by Mr. F. D. Adams, of McGill College, I started on the 22nd of June, with four canoeemen, from Grenville to Iroquois Chute, on the River Rouge, near Trembling lake. This point is forty-four miles in a direct line nearly magnetic north from the former

place, but by road is not far from sixty-five miles. This distance we traversed by teams, having arranged beforehand to secure our canoes at the Chute. Our object was to ascertain the characteristics and the relations of the lowest gneiss of Trembling mountain to the gneisses and limestone bands of Trembling lake; as well as to trace out the western boundary of the great anorthositic area of Wolfe, Grandison and Archambault and its extension through the area north-west of the latter township. In the examination of the Trembling lake area all the streams and lakes in the vicinity, to a distance of six to eight miles on all sides, were visited. Trembling mountain itself was ascended and its elevation above the surface of the lake at its front found by aneroids to be 1,720 feet, or within three feet of the elevation, as determined by Sir William Logan in 1858 by triangulation. This added to the elevation of the upper terrace at Iroquois Chute, taken from the railway survey to this point from St. Jerome which is here stated to be 875 feet above Lake St. Peter, and which is approximately the same as the surface of Trembling lake, would give for the summit of this mountain a height of about 2,585 feet above the sea. From the Iroquois Chute we ascended the Macaza river, and thence up that stream and its branches to the height of land between there and the lakes at the head of the west branch of the Devil's river. Thence by portage we reached Lac des Baies and ascended the west branch of the Devil's river to its junction with the north branch, a short distance from Devil's lake. This stream is not laid down on any map, and, in fact, this section of the country is entirely unknown to any except a few hunters who occasionally cross by this route to the waters of the Mattawin. The surface is largely drift-covered and ledges are rarely seen even around the lake shores. From the Devil's lake the main stream (Devil's river) was descended to its junction with the outlet of Trembling lake; a track survey being made for about thirty-five miles. The stream is in places very rough and presents huge cliffs of gabbro at several points. By this survey the western limits of the anorthositic area above referred to can be fixed. Finding, however, that the relations of the limestones to the associated and generally underlying gneiss could not be so satisfactorily determined in this area as in that further south, owing to the prevalence of the drift, and there being no further funds at our immediate disposal, the canoe men were brought back to Grenville by team as being the cheapest and most expeditious way and there paid off. In consequence of there being no map of the country north of the Ottawa river, in the counties of Argenteuil and Ottawa, on which the roads were laid down with any approach to accuracy, the survey of this area was taken up in company with Mr.

Deeks, who had already surveyed most of the roads in the flat country between Lachute and the Ottawa and extending west to Calumet. The greater part of the roads in the counties just mentioned, as far west as Thurso and north for ten miles beyond the Iroquois Chute on Rouge river, have now been surveyed, partly by pacing and partly by wheel survey, and from these a skeleton map of this district is now being constructed on which the distribution of the limestone bands will be shown at many points, but another season's work, devoted to the examination of the many lakes which are scattered throughout the district, will be required before the exact relations of the gneiss and limestone bands can be determined. All the roads between Point Fortune and the province boundary, on the east, and the South Nation river on the west, were surveyed to a distance of ten to twelve miles south of the Ottawa river, and the boundaries of the Calciferous, Chazy and Trenton finally revised. Much of this area is also largely drift-covered, but where rock exposures are seen they are generally highly fossiliferous, so that the determination of the formations named is comparatively easy. Good collections of fossils were obtained from various points near L'Orignal and Little Rideau, at both of which places Mr. Deeks found extensive quarries had been opened.

"The eastern outcrop of the anorthosite area through Wolfe, Beresford and further north and east in the county of Montcalm was traced by Mr. Adams, while in Howard and Morin its limit was noted by Mr. Deeks. Owing to the present unfinished condition of the work in Argenteuil and Ottawa counties conclusions cannot be stated. The Laurentian gneiss and limestone at Lachute are overlain by the Potsdam, of which a good exposure is seen about a fourth of a mile east of Lachute station, north of the Canadian Pacific railway, which is apparently conformably overlain by ledges of fossiliferous Calciferous rocks, the fossils being obtainable from ledges in the North river, near the paper mills, at a very low state of the water only. The Calciferous apparently extends thence to the Ottawa, though much of this area is heavily covered with drift, but at Carillon nearly horizontal Chazy sandstones are exposed which extend thence up to Grenville. At St. Andrews a prominent ridge of Laurentian red gneiss begins on the east side of the North river and extends for about seven miles eastward with a breadth of about two miles. This has not before been noted. It is separated from the area north of the Lake of Two mountains by ledges of Potsdam sandstone. The general attitude of all the fossiliferous strata in the vicinity of the Ottawa river and for some miles to the south is horizontal.

"The limestone of the Laurentian system in the county of Argenteuil would appear from the observations of the past season to represent its upper portion. They are generally seen to occupy synclinals in the gneiss and a succession of these limestone synclinals with gneiss anticlinal can be traced for many miles across Argenteuil and Ottawa counties. The limestones hold inclusions of rusty gneiss which have once existed as interstratified bands and have been drawn out and frequently twisted into curious forms. Scattered crystals of apatite, pyroxene, graphite and sometimes garnet occur in these beds, and often fragments of crystalline orthoclase which on weathered surfaces stand out prominently, and at first sight cause the rock to assume the aspect of a conglomerate. The lower portion of the limestone bands are associated with layers of quartzite and rusty gneiss, with beds of a whitish highly felspathic rock, and these are generally repeated regularly on each side of the limestone synclinals, passing downwards into greyish, greyish-red and reddish gneiss. The general strike of the rock is a few degrees east of north, but at several points the direction changes to nearly east and west and occasionally the various members appear to be overturned. It has been found very difficult to trace the limestone areas continuously, owing in part to these being to a large extent concealed by drift, but also to the fact that many of them are local in their development, as can be seen by their frequently thinning out and ending often quite abruptly both to the north and south. In the northern part of Argenteuil the limestone decreases in development and on the branch of the Upper Rouge called the Macaza disappear altogether; this may, however, be to some extent due to the covering by drift, but not altogether. East and north of Lachute the beds of limestone also become very limited, but going west through Grenville, Petite Nation, &c., they become much more extensively developed.

"The economic features of the district examined by us north of the Ottawa, in Argenteuil and eastern Ottawa counties, are at present comparatively unimportant. Deposits of mica, graphite and asbestos occur quite frequently, and some of these have been opened up but no mining has been done in this section for many years. The most easterly observed outcrop of serpentine limestone, with asbestos, was at Silver lake, half a mile south-west of the inland lake at Wentworth. The asbestos veins were few and of small size. Small crystals of apatite and pyroxene were observed in limestone near Maskinongé lake, one mile and a-half south of St. Jovite in Grandison, but nothing of economic importance was noted.

"The party left Ottawa on the 8th of June and returned on the 14th of October. Expenses of the season \$1,136.

Roads surveyed by waggon wheel	850 miles
do do pacing	110 do
Track survey of Devil's river.....	25 do

"My associates during the past season were Messrs. W. E. Deeks, B.A., Robert MacDougall, B.A., and J. F. E. Johnston, Graduate Royal Military College, Kingston."

Mr. F. Adams, of McGill College, kindly undertook to complete the examination and mapping of the Laurentian area which lies to the north of the Island of Montreal and on which he had been working before he retired from the survey in 1890.

On this work he furnishes the following interesting report :—

"Leaving Montreal on June 22, I joined Dr. Ells at Grenville the same afternoon and proceeded at once with him to Chute aux Iroquois and Trembling lake where we arrived on the 24th of June, this district being on the line between the map above referred to and the sheet adjoining it to the west, which is being surveyed by Dr. Ells. The special work to be accomplished in this district was the determination of the limit to the north-west of the great Morin anorthosite area and the relation of the limestone bands to it. The former was fixed by a track survey of the Devil's river, an exceedingly rough stream, which runs in a southerly direction through the township (not yet named) lying northwest of Archambault and joining the outlet of Trembling lake about a mile from the lake. The study of the relations of the limestone bands to the anorthosite, however, was less satisfactory, large exposures of the former being found, but their relation to the anorthosite could not be determined, in most cases owing to the heavy drift which covers much of the country.

"No further reference to the north in this district is here required, as a report on it has been made by Dr. Ells. I returned to Grenville on the 22nd July.

"On the 4th of August I again left Montreal and remained in the field until the 27th of August completing my examination of various parts of the area, working as far east as the township of Brandon which was very carefully examined.

"The geology of the whole district, which comprises an area of about 4,000 sq. miles, in the counties of Berthier, Joliette, Maskinongé, Montcalm, Argenteuil and L'Assomption, has now been worked out and it is hoped that the map will be ready this spring. Speaking generally it will extend from Berthier in the east to Trembling mountain on the west, and from Cypress lake on the north to Lachute on the south.

"The area examined is occupied for the most part by rocks of Laurentian age, which to the south-east are unconformably overlain by Cambrian or Cambro-Silurian strata. The Laurentian rocks consist of gneiss in great variety, interstratified with beds of quartzite, amphibolite and crystalline limestone. In the eastern part of the area these strata lie nearly flat, but to the west they become more and more sharply folded. Sometimes interstratified with these and sometimes intruded through them are a number of masses of gabbro or norite rich in plagioclase (anorthosite). These, together with some of the associated gneisses and limestones, were formerly supposed to constitute a separate overlying series, to which the name Upper Laurentian was given. Their boundaries have, however, now been traced out, and their stratigraphical relations determined and they have been found to be without doubt igneous rocks, while the associated gneisses and limestones form part of the ordinary Laurentian complex. The 'Upper Laurentian,' therefore, in this typical area does not exist. In addition to these basic igneous rocks, masses of eruptive granite and other acid rocks occur in several parts of the district."

Mr. Giroux was requested to go over and revise the boundaries of the Palaeozoic formations north-west of the St. Lawrence, on the south border of the Three Rivers sheet and the adjoining north border of the Montreal sheet of the Eastern Townships map in the counties of L'Assomption, Berthier and Maskinongé. On this work Mr. Giroux reports as follows:—

"I left Ottawa on the 15th of July, but owing to some difficulty I had in getting good canoe men I could not begin work before the 25th of July, on which day a micrometer survey of the L'Assomption river was begun from the dam, a short distance above the old saw mill of the town of Joliette. This river is very crooked and affords very good exposures of highly fossiliferous brownish weathering calcareous sandy rock or impure limestone full of grains of quartz. The strata are nearly horizontal. Ledges of these rocks crop out here and there, in ascending the river, for a distance of about a mile and a quarter, where there are exposures of brownish weathering coarse whitish grey sandstone (Potsdam). The beds are disturbed and the rock is very much decomposed for three or four inches from the surface. At Bordeleau's mill, two small excavations had been made where the rock contains small bunches and strings of iron pyrites. The beds dip S. 60° E. < 12°. These sandstones extend as far up as Rapide à Nadeau, or about 19 miles, by the river, in a northerly direction from the town of Joliette. At the foot of this rapid there are ledges of coarse crystalline hornblende gneiss which soon changes into a more quartzose grey

gneiss. About one-third of a mile further up the river two farmers spent all their money digging for gold in patches of calcite which they mistook for quartz. The small scales of mica, the fine fragments of hornblende, and a few crystals of iron pyrites which shine in the rock are probably what led these men astray.

" We ascended the river to the mouth of Black river, and in all that distance, about 40 miles, the Laurentian rocks are well exposed ; they consist of gneisses which vary greatly in composition, being at times very micaceous, then hornblendic, and then again very highly quartzose and garnetiferous. As a rule the foliation is very indistinct, and it is only in very few places that the dip which varies in direction and from an angle of 27° to 37° degrees could be observed. The banks of the river are very irregular in height, varying from 25 to about 125 feet, and are composed of fine and coarse sand, with bands of small pebbles which are always underlain by bluish grey clay. In some places, however, the banks are all clay. As a rule rock exposures can be seen at rapids only ; but as these are numerous a good section is afforded. All along Black river from its mouth up to Black lake, a distance of seven miles, there are fine exposures of various gneisses. In some places it presents a mottled appearance due to patches of almost pure quartz, and others of hornblende and mica. In places the rock shows specks of graphite and iron rust. The predominating colour of these gneisses is brownish grey, weathering grey and having a general strike of N. 30° E. to N. 30° W.

" Black lake measures about six miles around and has low shores which are even swampy in places. In the bottom of the largest bay known by the name of 'Monatac bay,' an old Indian by the name of Monatac settled about 60 years ago and reported that he had a gold mine near his shanty which was generally believed. Even now, many persons in the district firmly believe that there must be a great deposit of gold there. I examined the spot and found ledges of grey gneiss containing yellowish brown mica, the old Indian's gold ! We then ascended Black river as far up as range line XIII-XIII of the township of Brandon. Thence, we portaged across to Lake Matambin which we surveyed, and then descended the river Matambin to Lake Maskinongé. Around Lake Matambin are ledges of brownish grey gneiss and grey mottled yellowish quartzite, micaceous where the banding is distinct.

" Matambin river is very crooked and is of very little geological interest, as it shows only one small exposure of dark hornblendic gneiss from its head to its mouth.

" At the south-eastern end of Lake Maskinongé there are exposures of about 300 feet wide of a fine-grained reddish gneiss, much broken, reddish weathering and cut in different directions by irregular veins of reddish coarsely crystalline quartz-felspar and chlorite rock. More exposures of brownish grey and grey very highly quartzose gneisses can be seen on the west shore of the lake from about a mile and a-half south of Matambin river; the foliation is very indistinct, but in some places it was distinct enough to determine the strike as S. 31° E. with easterly dip. About a quarter of a mile from these gneisses are ledges of a reddish brown, fine-grained, compact, highly felspathic rock. This extends to a cliff of about 150 feet high and about 700 feet long, composed of much twisted and mixed quartzose felspathic hornblendic and micaceous gneisses. These and the above described rocks are the only ones seen on Lake Maskinongé, the shore of the northern part being low and sandy, and the rest of the southern shore covered with boulders.

" The survey and examination of Lake Maskinongé being completed, we ascended the Mastigouche river for a distance of fourteen miles. We then made a portage across the mountains to Lac à la Chute, two miles and a-half north-north-west. From the mouth of the river up to the portage there are many ledges of various kinds of gneiss to be seen dipping approximately S. 35° E. $< 25^{\circ}$. About a quarter of a mile from the mouth of this river there is a small exposure of a greyish quartzose calcareous rock, containing much white calcite in places and full of iron pyrites and rounded grains of a light green mineral (pyroxene). Hills of gravel and sand, 10 to 60 feet high, occur in places along this distance. Mastigouche river is very rough from the portage road above mentioned to Lac à la Chute. There are nine falls one after the other in this short distance. All the rocks are varieties of gneiss. Traces of magnetic iron ore occur in places, and in others large crystals of brittle black mica. The Mastigouche river was surveyed for about 20 miles north of Lac à la Chute before taking an easterly direction through a chain of small lakes which led us to two lakes, one being the head of the east branch of the Mastigouche, and the other the head of the west branch of the river Du Loup. These two lakes are separated by a band of gneiss only about 25 feet wide, and therefore the watershed portage was easily crossed. The country comprised between Lac à la Chute and 'Lac Sans Bout,' which is a few miles south of 'Lac au Sorcier,' is very poor both in timber and soil. The land is swampy and stony; scrubby spruce growing on rocks covered with very little decomposed vegetable matter and wet moss-covered surface gives the country a very uninviting appearance. From 'Lac Sans Bout,'

which is about six miles long, we proceeded to 'Lac au Sorcier,' and then down the river Du Loup, which was surveyed to its mouth. The timber in the neighbourhood of the two last mentioned lakes consists of spruce, tamarack, a few pines and scrub cedars, and is the best seen on all our route. The river Du Loup is very rough, and its bed is generally covered with immense blocks and boulders of gneiss. Good exposures of gneiss are often met with, and the rapids and falls there are on this stream from its head to a few miles below Hunterstown are too numerous to detail. At about 22 miles south of 'Lac au Sorcier' there are very fine exposures of grey gneiss, showing a much contorted banding, but with a general dip of S. 20° E. $< 20^{\circ}$. At Hunterstown there is a band of whitish grey micaceous limestone, about five feet wide, interstratified with the gneiss. No ledges of rocks newer than Laurentian can be seen on the river Du Loup. Fossils were collected from the following places: Chicot river, north of St. Cuthbert, Fafard's quarry, Defond's quarry and McGee's quarry, all close to one another, in the parish of St. Cuthbert, from Barrette's quarry in the parish of St. Barthélémi, Gagnon's quarry in the parish of St. Justin, and from many other places.

"The Canadian Pacific branch railway, from Joliette to St. Gabriel de Brandon, was surveyed, and also many roads, so as to fix the boundary of the Palaeozoic rocks and define as well as possible the different formations of the Cambro-Silurian, but the country being so much drift-covered, it is very hard, if not impossible, to do so accurately.

"A pretty good deposit of bog iron ore was observed in the county of Joliette, along the railway. The Canada Iron Furnace Co., of Radnor, began to work this deposit last July, and their foreman informed me in September, 1891, that he thought he would be able to ship about 200 car loads of the ore to the blast furnace in Radnor by the fall.

"Prospecting for gold in the Laurentian system, in the county of Joliette, has been going on for years, and there was quite an excitement created in the town of Joliette last summer about a gold mine having been discovered along the Brassard or Mattawin road at a place called 'La Barrière,' in the unsurveyed portion of the township of Courcelles. This place was opened and worked by a company styled: 'Compagnie des mines d'or de Mattawin.' In the report of the Commissioner of Crown Lands of the Province of Quebec for the year 1890, Mr. Obalski, the Government mining engineer, speaking of it says:

"From the latter property, several samples taken by myself in a small vein a few inches wide, were assayed by Messrs. Ladoux & Co.,

New York assayers, and while two of the samples gave no traces of gold, a third gave the following result:—

Gold, 1·83 oz. per ton of 2,000 pounds.
Silver, 2·65 oz. do

“I collected samples from the mine and Mr. Obalski was kind enough to give me some of the quartz of which Messrs. Ladoux & Co. report so favourably, and these samples were given to Mr. Hoffmann, chemist to the Geological Survey, to analyze and were found by him to contain only a trace of gold and no silver.

“I returned to Ottawa on the 6th of November, having during the season surveyed 315 miles of rivers, lakes and roads, viz., 215 miles of rivers and lakes by micrometer and 100 miles of roads by pacing. Expenditure for the season, \$806.”

Professor Laflamme was requested to make an examination of certain portions of the north-west shore of the St. Lawrence, between Malbaie and Tadousac with a view to revise and complete the delineation of the geological formations in that district. On this work Professor Laflamme reports as follows:—

“The Cambro-Silurian formations, so often seen in contact with the Archæan rocks along this coast, are generally extremely contorted. There are nearly everywhere traces of displacements and overturnings, in which respect they differ widely from the same formations as found in the neighbourhood of Quebec and Lake St. John.

“It seems to me that these perturbations, the complicated positions of the beds, the numerous fractures met with on all sides, might well have something to do with the slight earthquakes which occur generally several times in a year in this part of the country.

“From statistics which I have collected on the spot, these seismic phenomena have at present a tendency to diminish in intensity and violence. Yet it is quite probable that the maximums may recur from time to time, at intervals, which it is almost impossible to determine precisely.

“Observations on the earthquakes, as gathered from the inhabitants, are too divergent and contradictory to give any assistance in locating the centre or centres of disturbances.

“The only mineral of economic importance met with during the exploration is limestone. It is used for lime and for building stone. I have already mentioned in my last year's report the sandstone of Malbaie, which furnishes excellent building material.

"The limestone which occurs as a band of greater or less width along the coast disappears completely two or three miles below Malbaie. Thence to Tadousac, nothing but steep banks of Laurentian granite are met with. The general aspect of the country is absolutely the same as along the Saguenay shore, and the mineral composition of the rocks in both places is identical.

"At the request of a number of persons I have examined certain deposits of minerals which were thought to be of value. Unfortunately, none of them realized the hopes conceived of them."

Mr. Low, assisted by Messrs. H. Y. Russel, B.A.Sc., A. A. Cole, B.A., and J. B. de Boucherville, B.A., was engaged during the past summer in working out the geology, and in correcting and extending the topography of that part of the N.W. $\frac{1}{4}$ sheet of the Eastern Townships map between its eastern boundary and the St. Maurice river, comprising the southern portions of the counties of Champlain and Portneuf.

Mr. Low left Ottawa on the 9th of June, and was joined in Quebec by Mr. Russel, where a few days were spent tracing plans in the Crown Lands office and in examining the rock sections on the north side of the city. The boundary of the anorthosite area which extends eastward from behind Chateau Richer to beyond Ste. Anne de Beaupré, was traced to the limits of the N.E. sheet of the map. Men having been engaged the party proceeded to Rivière à Pierre station on the Quebec and Lake St. John railway, and there separated, one party, under Mr. Russel, to make pace surveys of the roads already mapped and chain surveys of new roads; and the other party, consisting of Mr. Low and two canoe men, to examine the rocks along the principal water courses.

The Batiscan river was first descended from Laurentides station to its mouth. The rock exposures along the river are numerous to within three miles of Ste. Geneviève where the country becomes low, and the river banks are cut out of deposits of stratified clay and sand.

Along the upper part of the river the rocks are tilted at high angles, and are much contorted both on dip and strike; but throughout the part below Nôtre Dame des Anges the dips are quite moderate and are almost always towards the east. At Nôtre Dame a large area of massive quartzite is seen, having a breadth of over one thousand yards; this passes gradually into a light coloured quartzose mica gneiss on both sides. Quartz veins penetrate the quartzite and hold large crystals of a light coloured mica, along with black tourmaline and hornblende. A small crystal of apatite was also found here. Some of

the mica is large enough to be of commercial value, but is often considerably crumpled. The St. Maurice river was next examined from the Grandes Piles to its mouth. The rocks here were found to be like those of the lower part of the Batiscan river inclined at low angles towards the east. The gneisses have a more basic character than those to the eastward, and in many places ilmenite or titanic iron ore is a constituent mineral. This is generally found in small grains disseminated through the rock, but at times is found in larger masses, chiefly in pegmatite veins. White and red crystalline limestone occurs in small bands or veins in several places near the Petites Piles; it is rendered impure by a large mixture of green pyroxene and yellow mica.

The next exploration was from Lake Edward to the St. Maurice river, coming out on that stream at La Tuque. This journey was made by an old overgrown portage route which leaves Lake Edward on its west side opposite the Grand Island, traversing five small lakes on the headwaters of the Petite Vermilion river and five others on the Petite Bostonnais river into Little Wayagamack lake, and thence by Lake Wayagamack and the latter river into the St. Maurice, some three miles below La Tuque. The Wayagamack lakes are fine bodies of water, the smaller having a shore line of nine miles, the larger of twenty-six miles; both lakes are surrounded by fine wooded hills, and their clear water is full of large trout.

From La Tuque, the St. Maurice river was descended to the Grandes Piles; numerous bands of white crystalline limestone were noted at different points along the river occurring in a basic ferruginous gneiss. The largest mass of this limestone is found in the second range in the township of Polette, two miles inland from the river; here the exposures show a development of white limestone over four hundred yards wide which is said to extend inland some three miles further. Much of this limestone is fine-grained and free from impurities, while the remainder is coarser grained and holds reddish mica, green pyroxene and traces of graphite. Crystals of mica are said to have been found here, but no specimens of it that would be of economic value were seen.

On a point about one mile above the mouth of the Mattawin river is a large vein of dark red pegmatite holding masses of magnetite, the only known locality in this region of such ore free from titanic acid.

The next canoe trip was taken through lakes Long and Mekinac, the last being a fine body of water some fourteen miles long with perpendicular cliffs on the east side, rising in places six hundred feet above the lake. Its water is clear and very deep, as a chance sounding gave two hundred and sixty-five feet. The cliff on the east side gives

an almost uninterrupted section, which shows the gneisses to be arranged in a series of folds, with high dips to the westward and low ones towards the east. A few small veins of crystalline limestone were seen near the axes of the anticlinals. The discharge of Lake Mekinac was followed to its discharge into the St. Maurice river. On the north side of the Mekinac river and along a tributary flowing out of Trout lake, large masses of iron ore have been found in a dark greenish red gneiss composed chiefly of orthoclase and epidote, but as all the ore yet found contains a large percentage of titanic acid it is practically of no value. Similar ore is found in a large quartz vein, on the west side of the St. Maurice river, about seven miles above the Grandes Piles and near Lake Bouchard, in the Seigniory of Radnor, also in the township of Shawenegan, and about the lakes of the Laurentide Fishing Club. In the vein at Lake Bouchard a small mass of apatite was found associated with the iron, mica and pyroxene.

On the 6th of August the road surveys having been completed, that party was disbanded, Messrs. Cole and Boucherville returning home and Mr. Russel joining in the canoe work.

The Black river was explored from the crossing of the Quebec and Lake St. John railway as far as its junction with the Ste. Anne river, and then a trip was made from Lake Edward to Lake Batiscan by way of the Lac des Passes route, the return journey being down the Eclair river, the discharge of Lake Batiscan.

The rock sections along the new line of railway from Rivière à Pierre to St. Tite junction were next examined and were followed by a canoe trip through lakes Long Masketsy and Roberge to the head-waters of the Eaux Mortes river, which was descended to Lake Mekinac; thence a portage route was followed through Trout, Sleigh, Castor and Batiscan lakes to the St. Maurice. The remainder of the season was taken up visiting the mineral localities of the region and in a short trip up the Jacques Cartier river for a more detailed examination of some of the rocks exposed in the adjacent country.

At Lac Tortue the Canada Iron Furnace Company have lowered the water of the lake some four feet, and as the lake is very shallow with slightly sloping banks, a large area is laid bare around its edge, and here the bog-iron ore which has been formed in the lake as flat concretions is washed out of the surface mud with hand sieves, while the ore in the deeper part of the lake is raised by a dredge which carries three rows of buckets on an endless belt.

Apart from Lac Tortue, in all the flat country about Three Rivers on both sides of the St. Lawrence, bog-iron ore is found in patches which vary from three to eighteen inches in thickness. The ore is

gathered by the farmers from their lands, and brought in and sold at the furnace. As iron smelting has been in operation about Three Rivers since 1737 the supply of ore in the vicinity is somewhat exhausted, but new supplies of great extent have been found about Gentilly, opposite Three Rivers, and along the Joliette branch of the Canadian Pacific railway, so that enough ore will be forthcoming to run the new furnace at Radnor which will have a capacity of thirty to fifty tons a day, smelting magnetite from St. Jérôme along with the bog ore.

Ochre is a common mineral in this part of the province and is at present worked in two localities at St. Malo, eight miles from Three Rivers, and at St. Tite junction on the Piles Branch railway.

At St. Malo the deposit has been proven across twenty-two lots and in width from one hundred to three hundred yards, with a depth from one to twenty feet. At St. Tite junction the ochre occurs in two gulleys which join, and run into the St. Maurice; the ore has been proven along both gulleys for nearly half a mile and has everywhere a considerable thickness.

The St. Maurice Metallic Paint Co. and the Johnson Paint Co. have furnaces for burning the ore at St. Malo, the former grinding the burnt material at Cap Magdeleine near Three Rivers, the latter at Montreal. At St. Tite junction a furnace and grinding mill are in course of erection by the Radnor Paint Co. During the summer upwards of five hundred and fifty miles of canoe exploration was accomplished in the northern portion of this region, together with eighteen miles of chained and four hundred and eighty-three miles of paced survey along the roads of the settled southern area. Total cost of the exploration \$1,414.06.

Mr. Robert Chalmers left Ottawa on the 6th June for New Brunswick with instructions to continue the detailed survey and mapping of the superficial deposits in the counties of Westmoreland, Kent, Albert and Northumberland, and the investigation of the glacial phenomena connected with these deposits. The following is his report on the progress of this work:—

"The maritime parts of this area have now been pretty thoroughly studied. But the district drained by the south-west Miramichi river requires further exploration, especially that portion lying to the west of the main river, and another season's work will be necessary to complete the whole.

"A great part of the area examined is level or slightly undulating, but in Albert county it is hilly and broken. Around the head of

the Bay of Fundy the surface is diversified by ridges which attain a height of from 200 to 400 feet. Between these, tongues of salt marsh extend up the valleys. These marshes are a characteristic feature of the scenery.

"The surface geology of this part of New Brunswick is of profound interest; and the glaciation of the isthmus of Chignecto, in its relation to that of the mainland of New Brunswick and of Nova Scotia, is of special importance. The facts when studied in detail will, in my judgment, show the action of floating as well as of land-ice. On the site of the marine railway, now under construction across the isthmus, and along the New Brunswick and Prince Edward Island railway, the exposed ledges exhibit *striæ* varying from S. to S. 50° W. (true meridian). These have been produced by ice moving across the isthmus from the north-east. And as no high land exists in that direction nearer than Labrador or Newfoundland, the hypothesis of their having been caused by floating ice during the Pleistocene subsidence of the land here seems a reasonable one. This view is supported by the facts respecting the glaciation of the higher grounds on both sides of the isthmus. In Eastern Albert and in Westmoreland and Kent counties, N.B., the *striæ* indicate ice movements directly towards the Bay of Fundy and Strait of Northumberland, while in Cumberland county, N.S., the land-ice appears to have moved down the slopes westwardly towards the open Bay of Fundy, or Pleistocene sea, then forming a strait between New Brunswick and Nova Scotia. On the whole, the district is one offering special advantages for the study of the relative movements of land and floating ice.

"An increased interest was given to the study of glacial phenomena and Pleistocene changes of level by the visit in October of Baron G. de Geer, a member of the Geological Survey of Sweden, who is actively engaged in similar investigations for that survey. He made special investigations in New Brunswick respecting the height of the Pleistocene shore line, or, as he terms it in Scandinavia, the 'marine limit,' and by independent measurements made at St. John, Moncton, Bathurst and Dalhousie junction he found that this limit of the marine beds, as laid down by me, is approximately correct. The hypothesis that the Pleistocene upheaval was greater in New Brunswick than in Nova Scotia was sustained by observations made by Mr. Wilson and myself later on. East of Nappan river, N.S., we discovered a well-defined shore line 135 feet above high tide level and traced it upwards of four miles. The importance of this Pleistocene 'marine limit' lies in the fact that when the land was at this level (viz., 225 feet at Moncton, N.B., and 135 feet at Nappan, N.S., lower than it is at the pre-

sent day), the Bay of Fundy would be connected with the Straits of Northumberland, and, consequently, those parts of the isthmus of Chignecto on which striæ are found would be submerged to a depth sufficient to allow floating ice to pass over them.

"A discovery of some importance made by Mr. Wilson was that of marine fossils in the boulder-clay at Negrotown Point, St. John Harbour. The deposit was also examined by Baron de Geer and myself.

"The recent and stratified deposits of Westmoreland and Albert counties are varied and interesting, and those of tidal origin, viz., the salt marshes, are unique. These marshes comprise, in Westmoreland and Albert counties alone, an area of 35,000 acres, and have long been noted for their fertility. Of late years, however, they have deteriorated. This remark applies more especially to those portions which have been dyked and cropped continuously for a century or more, without the application of any fertilizing material to the soil, which has, in consequence, become deficient in plant-food. Lime and wood ashes have been recommended; but improving them in this way is slow and expensive. A scheme inaugurated by the more intelligent farmers of Sackville would, if systematically carried out, be more effective and economical, viz., the cutting away of portions of the dykes and aboideaux and flooding the marshes with the tidal waters of the Tantramar and other rivers, which flow through them. The tides, which rise high enough to overflow these marshes, if the dykes were broken, carry in red mud and deposit it on their surface. This is an admirable fertilizer, its efficiency having been abundantly proved by the experience of the Sackville farmers. This system of improving them will probably be adopted by all the owners of exhausted marsh lands around the Bay of Fundy. It seems the natural method of restoring them, partially at least, to their original fertility.

"The depth of the marsh mud is variable, but increases seaward. Immediately underlying it is a layer of fossiliferous blue clay, which rests on a peat or forest bed. At Aulac, Intercolonial railway, the latter attains a thickness of 20 feet, and is overlain by 80 feet of marsh mud. These marsh and peat beds indicate, therefore, a subsidence of the land here within the recent period of about 80 feet. Intelligent observers inform me that the peat or forest bed is continuous or nearly so, throughout, underlying the salt marshes everywhere.

"In reference to the soil on the higher grounds, it may be stated that the eastern part of Westmoreland county comprises some of the best agricultural lands in the province. Along the Petitcodiac river there are also fine farming tracts. On the Millstone Grit area, how-

ever, the soils are deficient in lime, and would be much benefited by frequent applications of it.

"In Westmoreland county, the forest growth is recent, except in a few limited areas. The more extensively wooded portions of Albert and Kent counties are, however, covered by the original forest, which still contains large spruce, hemlock and hardwood trees. In the last-mentioned county, forest fires are rapidly destroying the timber tracts.

"The materials of economic importance found in the surface deposits of the district examined may now be briefly referred to.

"Bog-manganese occurs in Albert county, near the Dawson settlement. On a branch of Meldona creek, an extensive bed of it has been opened up, and a branch of the Albert railway constructed to it. Kilns for drying the material have also been erected. This deposit covers about 25 acres of ground, and appears to be quite thick—in one opening the thickness being 26 feet. The ore is a loose amorphous mass, which can readily be shovelled up, and contains, in layers and patches, a considerable percentage of bog-iron ore, or red ochre. Indeed, very little of the material appears to be wholly free from iron, though large portions have merely a trace of it. The deposit lies at the foot of a hill, and its accumulation there appears to be due to springs. These are still running down the hillside, and, doubtless, the process of producing bog-manganese is still going on. Operations have temporarily ceased at this mine. Indications of other and similar beds of bog-manganese have been met with at the base of this hill further west.

"Bog-iron ore was found on the south side of Buctouche Harbour, Kent county, occupying an area of several acres. Where openings were made in two places, the deposit showed a thickness of from 12 to 15 inches.

"Just south of Richibucto Head, another deposit of this material was observed, but its extent and thickness was not ascertained. Bog-iron ore was also noticed on the south side of the mouth of Kouchibouguac river by Mr. Wilson, and in a number of other places. No use has yet been made of it.

"Peat bogs occur at Richibucto Head inside of the sand beaches, also along the Kent Northern railway above Kingston. Two bogs were seen along the Intercolonial railway between Berey's Mills and Canaan stations. Smaller peat bogs were noted on the isthmus of Chignecto, and in numerous other places.

"Brick kilns are in operation at Lewisville, near Moncton, and at Folly Point, Westmoreland county, deposits of brick clay are common in many parts of the district.

"Gravel pits have been opened at Albert, on the Albert railway; at Memramcook (gold is reported to have been found in the latter); at Westmoreland Ridge, near Aulac, and on the Kent Northern railway, near Mill Creek, gravel and sand deposits are quite abundant in the district.

"My assistants during the season were Messrs. W. J. Wilson and W. D. Matthew, of St. John, N.B. Mr. Wilson, who has assisted me during part of four seasons, was in the field from the 1st of July to the 15th of August, and from the 14th of October to the close of field work, on the 20th November. Mr. Matthews was with me from the 15th of June to the 24th of July. Both these gentlemen performed their duties in every respect most satisfactorily. Mr. Wilson and I reached Ottawa on the 2nd of December, and he is now assisting in the preparation of the maps for publication."

The cost of the season's work, including the salaries of Messrs. Matthew and Wilson, to the 15th of August, is \$957.02.

Mr. Fletcher was instructed to continue the work of previous years in Nova Scotia. He left Ottawa for the field on the 17th of June and returned on the 15th of December. He was again assisted, during the entire season, by Messrs. M. H. McLeod and D. I. V. Eaton, and during several months by Professor Coldwell and Messrs. W. B. Almon and F. A. Coldwell.

Mr. Eaton, who was for some days employed in tracing and reducing plans in the office of the Iron Company at Londonderry, and in the Crown Lands Office at Halifax, did not reach Ottawa until the 24th of December.

Mr. Fletcher's summary of the season's field work is as follows:—

"The observations and surveys during 1891 were chiefly in the counties of Colchester and Cumberland, in the districts of Onslow, Londonderry, Economy and Parrsboro', north of Cobequid bay and Minas basin, comprising an area of about 500 square miles.

"The head of Cobequid bay presents many thousand acres of dyked marshes under excellent cultivation and the upland also is fertile. Numerous thriving, pretty villages dot the low shore as far as Economy, below which the scenery is strikingly wild and picturesque, and the coast is well known to collectors for the abundance and beauty of the rare minerals found in its trap formation, no part of the world except the trap district of India being, according to Professor Marsh, richer in zeolites than the shores of the Bay of Fundy. The mountains are for the most part under forest except in small settlements or where

tracts have been cleared in the neighbourhood of the Londonderry mines to furnish charcoal for iron smelting.

"The geological formations are the extension of those described in the Summary Reports for 1889 and 1890, comprising Triassic, Carboniferous limestone, Devonian and igneous rocks; and the additional evidence collected greatly strengthens the views expressed in those reports regarding their relations to one another.

"Red, soft, crumbly Triassic sandstone fringes most of the shore as far as Five Islands, below which it is only in small patches where protected from the fury of the tides—which rise to a height of 50 or 60 feet, with currents running eight miles an hour—by imposing precipitous capes and islands of basalt and amygdaloid built up in fine symmetrical columns or worn into deep caverns, pointed arches and lofty pinnacles.

"The Carboniferous limestone appears in the rivers or on the shore at several points between the head of Cobiquid bay and Economy. From Swan creek to the mouth of Parrsboro' river it rests in small patches upon Devonian rocks and the unconformity of these two series is well displayed; the former having the usual association of dark grey and red soft marl, sandstone and conglomerate with gypsum and fossiliferous limestone, while the latter consist of crumpled slates and quartzites, cut by igneous dykes, and by veins of limonite, ankerite, quartz, &c., but full of fossil plants and *Naiadites*. From another unconformable contact immediately west of Partridge Island, the Carboniferous limestone rocks occupy most of the shore as far as Port Greville, presenting remarkably fine illustrations of contorted and faulted strata, some of which have been greatly disturbed without affecting the beds above and below. Among these is a band of coaly bituminous shale, two feet thick, full of fossil plants, Crustaceans and *Naiadites*. Another belt of this formation extends from Phinney's brook to Spencer's island.

"The Carboniferous limestones have been quarried near Partridge island and at Clarke's Head. At another quarry at Kirkhill, two miles and a half north-west from Parrsboro', a dark grey flaggy limestone, in a nearly vertical attitude, includes lenticular layers of coal, one of which is said to attain a thickness of two feet at the bottom of a shaft 75 feet deep. The coal ignites readily, burns with a bright flame, leaving a light porous coke which yields a quantity of whitish or reddish calcareous ash. Another deposit of from two to four feet of slaty coal at Brookville was examined in 1878 by Mr. Scott Barlow. It has been opened by several pits in De Wolf brook, a short distance up stream, in a conglomerate composed of pebbles of the slates and quartzites of the adjoining brooks and of the shore, interstratified

with layers of soft argillaceous shale fit for whetstones and whitish quartzose sandstone. Other unimportant discoveries of coal have been made in the East River of Five Islands, Great Village river and other streams.

"The Devonian rocks are precisely like those of Riversdale, Union, Stewiacke and the coast of Hants county, described in the Summary Report for 1890. Sir Charles Lyell in 1843, while including the beds on the Shubenacadie river with the Carboniferous limestone formation, states that in five cases where Sir J. W. Dawson and he traced the junction, they found it to be a line of fault, and at the point of contact one face of the fault was in every case formed of gypsum. He further states that this is not in a rent or fissure, but seems to belong to the stratification which is nearly flat. In the Cobequid Hills, and also at some points on the shore, the Devonian rocks are intersected by masses of syenite and diorite. They come from beneath the Lower Carboniferous, on the shore between Moose creek and Partridge island, and again between Port Greville and Phinney's brook, where they are associated with a mass of crystalline limestone, apparently a vein. The iron ores of Londonderry—which give employment to 150 miners, and yield annually about 40,000 tons of ore—of Portapique and North rivers, of Birch Hill and other places, are also in these rocks as well as the veins of quartz, baryta, limestone and dolomite of Londonderry, Five Islands and Phinney's brook; while the asbestos (fibrous hornblende) of Lynn and Harrington river, and the altered diorites or serpentine, and the felsites of New Prospect occur among the associated igneous rocks.

"In addition to the fossils mentioned last year as having been obtained from the Economy river, in the neighbourhood of the gold (?) mine of Peleg brook, numerous stipes of ferns resembling, according to Sir J. W. Dawson, *Aneimites acadica* of the Lower Carboniferous, were found among the dark slates of Murphy brook.

"The newer or Triassic series of igneous rocks has attracted attention from all who have visited this district, and many of the contacts with the Triassic sandstone and other rocks have been minutely described. Along the line of junction the two are intimately mixed and angular masses of both are cemented into a sort of breccia passing into amygdaloid with cavities filled with zeolites. The amygdaloid contains magnetic iron ore in masses and veins one foot wide and under, exceedingly irregular in their course, and often terminating abruptly, so that little dependence can be placed upon them for mining although the ore is very rich. Of this nature are the iron ore deposits of Gerrish Mountain, Cape Sharp and Cape d'Or. Native copper and ores of this

metal and traces of manganese ores are also found in the trap. Collections of its characteristic minerals may be made from veins, nodules and geodes at Five Islands, Two Islands, Wasson's Bluff, Partridge Island, Cape Sharp, Spencer's Island, Cape d'Or and other places. The minerals referred to comprise amethyst of great beauty and brilliancy, moss and fortification agates of rich colours and varied surface, red and yellow jasper, pure white chalcedony of very fine texture and smooth surface, well adapted for cameos and other ornaments, and sometimes curiously zoned or marked with stripes of different shades of colour ; calc spar in rhombohedrons or of the dogtooth variety ; zeolites, including stilbite, heulandite, analcime, laumontite, thomsonite, chabazite and other species in beautiful crystalline aggregations or in perfect distinct crystals. Asbestos in small seams is found at Blue Sack.

"At the mouth of Fox river is a bank of fine sand, and great accumulations of drift sand, gravel and clay occur in this region."

The expenditure on the season's explorations, including the salaries of all assistants, was \$1,430.66.

Mr. Faribault continued and made good progress with the very excellent detailed work he is doing in mapping the structure of the gold-bearing rocks on the Atlantic coast of Nova Scotia and on which he furnishes the following report and interesting remarks. Personal observation enables me to concur in the opinion he expresses both as regards the correspondence of the Quebec gold-bearing rocks with those of Nova Scotia, and also as regards the position of the rich leads and their relation to axial folds. The latter, if correct, must prove of the greatest practical importance if intelligently applied in the further development of gold mining in Nova Scotia and also in directing prospecting for veins in the alluvial fields in Quebec.

"On the way to Nova Scotia, I took occasion to visit the Little Ditton gold district in the Eastern Townships of Quebec, with the view of comparing the Lower Cambrian rocks there with the auriferous series of Nova Scotia. Like all those who have examined both localities, I have no doubt that these auriferous rocks are of the same age. The Little Ditton rocks like those of Nova Scotia may be divided into two distinct groups, a lower or quartzite group and an upper or graphitic ferruginous slate group. They present the same lithological character as the two groups in Nova Scotia, and there are good reasons to believe that the gold of the Ditton alluvial deposits is derived, as in Nova Scotia, from numerous quartz veins which run along the sharp anticlinal axes into which these rocks have been folded. Although a great deal may be expected of the deep deposits of the old rivers which

have not yet been worked, the future of the gold mining industry in Quebec must as elsewhere lie in the working of the solid veinstone.

"The section surveyed this season in Nova Scotia lies westward of that surveyed in 1889 and 1890, and extends along the sea shore from Porter's lake to Halifax harbour, and northerly to the Shubenacadie and St. Andrew's rivers, covering an area of 305 squares miles in Halifax county and 70 squares miles in Colchester county. Besides this, Mr. Eaton surveyed 130 miles of roads in Hants county to be used as tie-lines in next year's contemplated work.

"The greater part of the region is occupied by the auriferous Lower Cambrian rocks cut by the western end of the belt of granite examined last year which extends to within two miles east of Waverley, and also by a small granite mass three miles north of Waverley. In the northern portion, the gold-bearing rocks are overlain by the Lower Carboniferous formation along the valleys of the Shubenacadie, Gay's and St. Andrew's rivers and a few of their tributaries.

"Two or three beds of dolomitic limestone from six inches to four feet thick were found at various places at the bottom of the upper graphitic ferruginous slate group, between layers of greenish talcose slate. These beds may contain fossils, but search made for them has so far proved unsuccessful.

"The anticlinal axes were minutely examined and traced, as in former years, on account of their close relation to the auriferous belts. Within the region examined, the geological structure of the gold district of Lawrencetown, Montague, Waverley and Oldham was carefully studied. Lawrencetown has been but little worked. The yield of the three other districts has been as follows :—

DISTRICTS.	Yield for 1890.	Total Yield from 1862 to 1891.
Montague	2,263	32,581
Oldham	2,775	41,242
Waverley	403	53,874
Total in Nova Scotia...	24,358	506,675

"Special attention was given to the gold district of Oldham, it being a typical district, worked to a great extent and exposing to great advantage the quartz leads, all of which were prospected by means of surface trenches on account of the small thickness of the drift. A detailed geological map of this district, on a scale of 500 feet to one inch, with sections, was compiled on the ground. It shows the elliptical structure of the anticlinal fold, with all the known quartz veins, both interbedded and transverse, and also the numerous faults affecting them, and proves clearly that the richness of a lead depends altogether

on its position and relation to the structure of the elliptical dome of the fold to which it owes its origin. In this work I am specially indebted to Mr. J. E. Hardman, B.Sc., M.E., manager of gold-mining properties in Oldham and Waverley, for much valuable information which his great experience in gold-mining enabled him to give.

"Auriferous leads have also been prospected at Elmsdale, South East Passage, and other places along anticlinal axes; and traces of antimony ore are reported to have been found at Wyse's Corner.

"Some facts which have an important bearing upon the question of deep mining, may here be introduced, in view of the great interest taken at present by the mining community in the subject. From a study of the districts east of Halifax, and especially of that of Oldham, it is plain that whenever an interbedded lead is followed some distance on the surface, or to great depths, its relation to the axis of the anticlinal, and consequently to the stratigraphy of the fold, is constantly changing, and its size and workable value must consequently be affected; so that it is improbable that a lead found rich and of good size on the surface can be followed profitably to great depths. The limit of depth may vary from a few feet to 400 or 800 feet according to the structure of the anticlinal fold, the position of the lead and the extent to which it has been denuded. The problem of deep mining seems thus to depend on the location of a zone of rocks containing the parts of the leads which are of sufficient richness, because they keep the same relative position to the axis of the anticlinal. In most of the districts the zone of rich leads has the anticlinal axis for its centre, and it is probably the centre of the auriferous zone to a depth practically unlimited. Such is the case in the eastern part of the province, at Seal Harbour, Isaac's Harbour, Goldenville, Harrigan Cove, Salmon River, Fifteen Mile Stream, Killag, Mooseland, Moose River, Caribou, Gold River, Lawrencectown, Waverley and Oldham. In the few other districts where the auriferous zone is worked only on the north or south side of the anticlinal, the zone would, for the same reason, be parallel to the axis of the anticlinal to an inaccessible depth, as in Isaac's Harbour, Wine Harbour, Beaver Dam, Tangier and Lake Catcha.

"I would, therefore, strongly recommend that deep perpendicular shafts be sunk on the anticlinals, and that cross-cuts be driven on both sides at various depths to test leads which do not crop out to the surface, many of which would probably prove very rich, as they would be cut in their most favourable stratigraphical position and could easily be worked by means of levels and overhead stoping from the cross-cuts and the one perpendicular shaft. This system might be adopted with advantage at the North Star property of Isaac's Harbour, at Golden-

ville, where both sides of the anticlinal have been worked from 500 to 600 feet deep and abandoned, but the middle of the auriferous zone has never been tried; at Fifteen Mile Stream, in the vicinity of the Serpent lead; at Moose River, where Mr. D. Tonquoy has his main shaft; at Waverley, on the east and west side; and at Oldham, west of the Black brook. No such systematic workings have, however, yet been undertaken in Nova Scotia, that I know of, except in Oldham, where Mr. J. E. Hardman began last summer to sink a perpendicular shaft on the anticlinal dome. The result of his undertaking is awaited with great interest.

"The pay streak of the leads in different districts is also a subject of great importance to miners, but, unfortunately, the data necessary to draw conclusions are very meagre, as in most of the mines, especially in old workings, no systematic records of the yield of different parts of the leads have been kept. I hope, however, to be able to throw some light on the subject from the notes I have gathered this summer.

"The materials of economic importance met with in the Lower Carboniferous comprise chiefly unexhaustible and valuable deposits of limestone and gypsum. One belt of fine grey limestone at Gay's River Corner carries a good percentage of argentiferous galena; it runs east and west, rests unconformably upon the lower quartzite group, was worked some years ago where the south-west branch of Gay's river crosses it, and also prospected last summer at Carroll's corner, where some mining areas were taken up.

"The gold district of Gay's river was reopened last spring by the Cole Stream Gold Mining Company, who put up an extensive 50 stamps steam mill and other large buildings. They sank a shaft, immediately north of Daniel McDonald's old works, which gave the following section of the Lower Carboniferous:—

	Feet.
Surface drift	20
Conglomerate containing gypsum, non-auriferous . . .	35
Coarse sandstone	2
Auriferous, irregular conglomerate	8

"This lower auriferous conglomerate is wholly composed of debris of the adjacent Lower Cambrian rocks, apparently in an old river bed, and rests on the lower graphitic ferruginous slate group. Beds of conglomerate similarly situated along the northern boundary of the gold-bearing rocks may prove sufficiently rich to be worked, but the great excitement caused two years ago by exaggerated reports of discoveries of gold in various places, remote from the gold-bearing rocks,

have led a great many to take up valueless ground. (See Summary Report for 1890, page 41.)

"The clay deposits on the Shubenacadie river, between Enfield and Shubenacadie railway stations, are well-known for their superiority for brick making, and brick yards have been in operation along the river bank for a great many years.

"Sand from the Dutch settlement is also used in New Glasgow for the manufacture of the best quality of glass and for moulding purposes.

"I was ably assisted, as in previous years, by Messrs. Archie Cameron and J. McG. Cruickshanks, for six months. I had also Mr. D. I. V. Eaton some two months surveying roads, and Mr. Walter C. Adams for two months.

"The season's work extended till 25th December, and the expenditure entailed, including salaries of all assistants, is \$1,420."

From the 17th of July to the 1st of October Professor Bailey, assisted by Mr. Lee Street, continued the examination and survey in south-western Nova Scotia which was commenced in 1890, and on this he reports as follows :—

"The earlier part of the season was devoted to the examination of portions of Queen's and Shelburne counties for the exploration of which there had not been sufficient time during the previous season. These include a large part of the district traversed by the Port Medway river; the Liverpool river from Lake Rossignol to Liverpool; Fairy lake, Tobeatic lake, Lake Rossignol and the associated smaller lakes; the Shelburne river, Broad river, the Roseway and the Clyde together with several islands off the coast. Particular attention was also paid, in accordance with your instructions, to the determination of the position and extent of the various areas of granite associated with the Cambrian rocks both along the coast and in the interior of the counties named.

"In the prosecution of this work it was found necessary, in consequence of the very irregular boundaries of the counties, as well as from other considerations, to extend the observations in some instances beyond the limits of Queen's and Shelburne to which they had previously been confined. A portion of the season was accordingly devoted to the examination of those parts of Lunenburg, Annapolis and Yarmouth counties which are immediately adjacent to those last mentioned.

"The results obtained in these explorations, together with those of the previous season, have been embodied in a report which will be immediately submitted. In attempting, however, to prepare a map to accompany this report, great difficulty has been experienced from the great want of accordance shown by the county maps upon which the field investigations are based. Not only do these differ in the position of lakes and rivers, and show numerous omissions, but even the same county lines upon adjoining maps, such as those of Shelburne and Yarmouth, though drawn upon the same scale, differ widely both in length and direction. Large tracts have, indeed, never been surveyed, and there does not appear to exist at present any materials from which anything like an accurate topographical map of the region can be constructed. The roads in the several counties which have been measured by odometer are fairly accurate, but a certain number of tie-lines, at least, are required to check the latter. Such maps as could be constructed from the data available will be submitted with the report."

Work under the division of Mineral Statistics and Mines was continued by Mr. E. D. Ingall, assisted by Mr. H. P. Brumell in the general work of the division, and by Mr. James White, who was engaged in making mining surveys in the iron and phosphate regions near the Kingston and Pembroke railway.

On the progress of the work under his charge, Mr. Ingall furnishes the following notes :—

"During last winter Mr. Brumell and myself were occupied with the usual work connected with the collecting of mining information, statistical and otherwise, for the annual report, and with the compilation and writing up of the same for publication. Besides this the usual preliminary summary statement of mineral production for 1890 was made up and issued in April. As far as the office routine connected with the above work would permit, advancement was made with the completion of a directory of mineral occurrences, and the representation of such occurrences on maps, several of which are now almost complete. In answer to inquiries a number of 'memoranda of information' have been issued, often embodying material the collection of which occupied in the aggregate much time.

"Mr. White has been engaged plotting his surveys and preparing the maps for publication required before the geological investigation of the Rivière du Lièvre phosphate deposits could be completed.

"These maps being available for use, it was considered advisable that I should during the summer, and as far as time permitted, attempt

the further field studies such as to enable a report to be issued embodying the results of these and previous investigations, which had been necessarily interrupted for some time on account of the pressure of other work.

"Before commencing this work, however, an effort was made to publish the annual report several months earlier than usual. All arrangements were made and the field work was set aside for that purpose, but meeting with insurmountable difficulties in connection with the printing, this intention had to be abandoned. The commencement of the field work was delayed until the 12th August, much fine weather was lost, and its continuance was necessitated as late as the 27th of November in order to complete the first sheet of the map of the du Lièvre phosphate district.

"During the above mentioned period the work done was altogether concentrated in the valley of the Rivière du Lièvre. The details of the pyroxenité belt on which are situated the High Rock, Union and other mines, had been as far as possible worked out during previous seasons. Recent developments, however, gave facilities for the extension of this work, and this belt was followed to the northern limits of the map, the High Falls mine.

"Most of the season, however, was spent in the study of the group of mines situated on the Little Rapids belt, and at the Emerald mine, all of which had necessarily received but limited attention before. The Little Rapids belt was traced for several miles with a view to obtain another instance of the continuity of these pyroxenite belts. Special attention was paid to the details of the rock structure, where the extensive and numerous exposures around the workings, gave a chance to accomplish this.

"The phenomena encountered being read by the light of the knowledge of the rocks of the district obtained during past seasons, presented many interesting points which will be set forth in the detailed report.

"During the latter part of the season I received very efficient aid from Mr. M. A. Bucke, who not only made topographical surveys around the mines, but also assisted generally in the geological work and rendered good service in the delineation of the rock areas.

"Owing to the fact that my own time was largely occupied during the summer and autumn in the above mentioned work, the field work connected with the collection of statistical and other information of a general kind, was necessarily intrusted to Mr. Brumell. During the summer he was engaged as in former years.

in visiting sundry mining districts in order to ascertain the extent and condition of the industries at these points. These examinations were principally confined to the provinces of New Brunswick and Ontario, and may be summarized as follows :—

“ In New Brunswick the following points were visited and investigations made :—

“ Gloucester county.—Development work was being actively prosecuted on a vein of argentiferous galena by Messrs. Payne and Ellis, of Bathurst. The vein is on Rocky brook, a branch of the Millstream. Work had also been done on a deposit of magnetic iron ore in the same vicinity.

“ Albert county.—Investigations were made in the southern part of this county, where a considerable amount of prospecting was being carried on, notably around Shepody mountain and to the westward, where on Sawmill creek a bed of mica-schist, said to contain gold, had been opened up. Work was being carried on as in previous years at the gypsum quarries of the Albert Manufacturing Company, at Hillsboro' and E. W. Lynd's, at Hopewell. Operations had ceased at the Crimora Manganese Company's property in Dawson settlement. A small amount of work had been done at Gawland mountain, without, however, sufficiently promising results to warrant further operations.

“ King's county.—The manganese property at Markhamville was still being operated, and although smaller quantities of ore were being obtained, active prospecting was being carried on by means of diamond drills. The manganese mine at Jordan mountain was idle. At Namavigewauk prospecting had been carried on to prove the gold bearing character of the conglomerate ridges of the vicinity. This work had been done under the auspices of the New Brunswick Mineral Developing Company.

“ St. John county.—A new plumbago property has been opened up at St. John, and a considerable amount shipped.

“ Victoria county.—Gypsum quarrying on the Tobique was being carried on as in former years.

“ Carleton county.—Apparently fruitless efforts were being made at the Britton mine, Woodstock, in search of the gold and silver promised by several assays made of picked specimens.

“ Charlotte county.—Considerable work had been done in prospecting for nickeliferous pyrrhotite on several bodies of which small shafts have been sunk.

“ Throughout the province there seems to have been a general revival of interest in mining matters.

"Visits were also made to various parts of the province in search of further information relating to structural materials.

"In Ontario, west of Toronto, visits were made to several central points for the collection of data regarding structural materials, petroleum and salt, as well as to Essex and Welland counties where boring operations in search of natural gas and petroleum were being actively carried on.

"In Hastings county, mining had been commenced by the South South Africa General and Developing Company, on a rich gold property in Belmont township, and on a deposit of magnetite in the same township by the Belmont Bessemer Ore Company of New York. At Belleville unsuccessful efforts had been made to obtain natural gas by boring.

"Mr. J. White's surveys in the Kingston and Pembroke railway district, already mentioned, were continued with a view to illustrating the mineral developments there. To this end it is proposed to make detailed surveys of the chief mines and also the roads and other topographical features serving to show the conditions of economic mining development in the district.

"During the summer, surveys were made of the roads in the northern part of the district with odometer and compass. The principal iron and phosphate mines were mapped, but otherwise the time at disposal and the nature of the country did not permit of any very accurate or detailed topographical work. As the iron mines had been closed for some time, the pits and underground workings were all full of water and any information relating to them had to be gleaned from outside sources. Another season's work will be necessary to complete the information for the map. During the past year no iron ore was raised in the district and but little phosphate, nearly all the mines producing the latter closing down in July and August.

"Mr. White's field work was begun on the 17th of July and completed on the 9th of October."

Since their return from the field, Mr. Ingall and Mr. Brumell have been occupied with the usual routine and with the detail of the office work connected with the material for the Annual Report. Mr. White has been engaged since his return in making additions and corrections to the topographical sheets of the map of the Rivière du Lièvre district, which were rendered possible as the result of surveys made during the summer. The manuscripts of these are now complete, and the engraving of the upper half is nearly finished, so that the topographical edition should be shortly available. The geo-

logical notes for these must await the elaboration of the material resulting from the field studies, but will be proceeded with as soon as possible.

The expenditure for field work in connection with the above surveys and examinations was as follows :—Mr. E. D. Ingall, \$772.70 ; Mr. H. P. Brumell, \$771.88 ; Mr. J. White, \$984.96.

CHEMISTRY AND MINERALOGY.

Reporting on the work of this division, Mr. Hoffmann says :

“The work in the chemical laboratory during the past year, has been carried out upon the same lines as those heretofore followed. It was chiefly confined to the examination and analysis of such minerals, &c., &c., as were considered likely to prove of economic value and importance. The ground covered included :—

“1. Analyses of fuels, comprising a semi-anthracite and coals from various localities in British Columbia, all of which proved to be of excellent quality.

“2. Analyses of mineral waters and brines. Of the former, some of those from British Columbia may not improbably, judging from the results of a qualitative analysis, prove of therapeutic value. Some of the latter belonged to, and constituted the last of, a series of saline waters—the examination of which had been commenced in the previous year—representing all the principal salt-springs on Swan and Winnipegosis lakes in the province of Manitoba, and on the Red Deer river, district of Saskatchewan, North-west Territory. The object of the inquiry was to ascertain if these brines could be advantageously used for the manufacture of salt.

“3. Analyses of limestones and dolomites. In continuation of the series of analyses of limestones and dolomites already carried out in connection with an inquiry into the individual merits of a number of these stones—from various localities—for structural purposes and suitability as a flux in smelting iron and lead ores or as a glass-making material.

“4. Analyses of nickel and cobalt ores. The greater number of the specimens examined consisted of pyrrhotite from various localities in the districts of Nipissing and Algoma, province of Ontario. These were all found to contain a satisfactory percentage of nickel. A pyr-

rhotite from what is reported to be an extensive deposit, in Charlotte county, New Brunswick, was also examined and found to contain 1·72 per cent nickel, 0·16 per cent cobalt, and 0·31 per cent copper. This material closely resembled much of the ore found in the above mentioned districts. Besides these, many other samples of pyrrhotite from other parts of the Dominion were examined.

Reference may, not inappropriately, here be made to certain other nickeliferous ores, the occurrence of which has been pointed out in previous reports of this Survey. One of these, a steel-grey pyritous ore, from the Wallace mine on Lake Huron, contained 13·93 per cent nickel; whilst of two others found on Michipicoten island, Lake Superior, the one, consisting of an intimate mixture of the arseniurets of copper and nickel, was found to contain from 17·03 to 36·39 per cent nickel, and the other, a hydrated silicate of nickel, gave, after drying at 100° C., 23·91 per cent nickel.*

"5. Gold and silver assays of ores from the provinces of Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia. The greater number coming from the last named province.

"6. Analyses of iron ores from the provinces of Nova Scotia, Ontario and British Columbia.

"7. Miscellaneous examinations. These include the partial analysis or testing, as the case might be, of brick and pottery clays, cement-stones, phosphatic rock, graphite, talc, &c., &c. The talc referred to was almost snow-white in colour and would appear to be almost, if not quite, as well adapted for use as a 'filler' in the manufacture of paper, as the talcose mineral found at Edwards near Gouverneur, Saint Lawrence county, in the state of New York.

"In addition to the work included under the foregoing headings, examinations and analyses have been made of several minerals recently met with, and now for the first time identified as occurring in Canada. The more important, from a commercial standpoint, of these are:—Gersdorffite, nickel arsenosulphide, a rich nickel ore from the township of Denison, district of Algoma, and Danaite, a cobaltiferous variety of mispickel, a useful ore of cobalt, from the township of Graham, also in the district of Algoma. These, with some others of more purely scientific interest, add materially to the list of minerals already known to occur in Canada.

"Amongst the many specimens received in the course of the year, were three of more than usual interest, viz., samples of cinnabar ore

* Geology of Canada, 1863. Chap. XVII, XIX, XX, pp. 505-7 ; 614 and 737-38.
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and native mercury from Seshart channel, Barclay sound, Vancouver island, British Columbia, and a sample of native platinum found, in association with gold, on the bars of the North Saskatchewan river, in the neighbourhood of Edmonton, district of Alberta, North-west Territory. Native platinum had previously only been met with in Canada in British Columbia and, in small quantities, in Beauce county, in the province of Quebec.

"During the period in question, seven hundred and five mineral specimens were received for the purpose of identification or the obtaining of information in regard to their economic value. The greater number of these were brought by visitors, and the information sought in regard to them was not infrequently communicated to them at the time of their calling. In other instances—those where a more than mere cursory examination was called for, or a partial or even complete analysis was deemed desirable, as also in the case of those specimens which have been sent from a distance—the results were communicated by mail. The number of letters written, chiefly in this connection, and generally of the nature of reports, amounted to two hundred and ninety, and the number of those received to one hundred and sixty-one.

"Mr. R. A. A. Johnston has diligently applied himself to, and most satisfactorily carried out, the work entrusted to him. In addition to the gold and silver assays, analyses of limestones, dolomites and nickel ores, he has conducted a great variety of miscellaneous work. Mr. F. G. Wait was principally engaged in the analysis of mineral and other saline waters.

"On the work connected with the mineralogical section of the museum, I have been most ably and zealously assisted by Mr. R. L. Broadbent. He has been engaged in the permanent labelling of specimens—a work which must of necessity be a more or less continuous character by reason of the many frequent additions to the collection; the readjustment of some of the cases, incident upon the introduction of several new table-cases, for the purpose of allowing of a more systematic arrangement of the economic minerals of some of the provinces—and in maintaining the collection in general in an orderly condition.

"The catalogue of this section of the museum, in the preparation of which I have had the hearty co-operation of Mr. Broadbent, will appear in the course of the coming year (1892).

"Very many of the mineral specimens have been replaced by more characteristic ones, and the collection augmented by the addition of

some one hundred and twenty others. Of these, the following were collected by members of the staff:—

1. Ami, H. M. (Survey) :

Argentiferous galena from the Elizabeth claim, Fish river, West Kootanie district, British Columbia.

2. Bailey, Professor L. W. (Survey) :

(a.) Staurolite from North East Harbour, Shelburne county, Nova Scotia.

(b.) Garnet on diorite from Chegoggin, Yarmouth county, Nova Scotia.

(c.) Garnet rock from Chegoggin, Yarmouth county Nova Scotia.

3. Barlow, A. E. (Survey) :

(a.) Cyanite, seventy specimens. (b.) Fibrolithe, eight specimens.

(c.) Gersdorffite, ten specimens. (d.) Huronite, forty specimens. (e.) Niccolite, six specimens. (f.) Nickeliferous pyrrhotite, one hundred and twenty specimens. (g.) Oligoclase, eight specimens. All from the Sudbury district, province of Ontario.

4. Brumell, H. P. (Survey) :

(a.) Petroleum from Walker's 'No 2' well, Marshfield, south-west corner of lot 11, range IV, of Colchester, Essex county, Ontario.

(b.) Petroleum from St. Joseph, parish of Dorchester, Westmoreland county, New Brunswick.

5. Dawson, Dr. G. M. (Survey) :

Coal from the Canmore mine, one mile from Canmore station on the line of the C. P. R., south-east side of Bow river, district of Alberta, N. W. T.

6. Ferrier, W. F. (Survey) :

About two hundred specimens of scheelite, tungstate, &c., from lot 1, range VII, township of Marlow, Beauce county, Quebec.

These include many fine and rare crystals, as well as a few large specimens suitable for the economic collection.

Ninety specimens of the silver ores from lots 1, 2, 3, and adjoining ones, ranges XIV, XV, and XVI, Risborough town-

ship, and lot 1, range VII, Marlow township, Beauce county, Quebec ; also about twenty-five specimens of minerals associated with these ores, some of which have not yet been fully identified.

6. Giroux, N. J. (Survey) :

Chromite (two specimens) from the townships of Leeds and Thetford, Megantic county, province of Quebec.

7. McEvoy, J. (Survey) :

Muscovite (three specimens) from near the junction of Canoe river with the Coldwater, British Columbia.

8. McInnes, W. (Survey) :

(a.) Argentite with pyrite, fluorite and calcite, from the Beaver mine.

(b.) Argentite and sphalerite with fluorite from the Beaver mine.

(c.) Argentite with native silver, and sphalerite, in calcite and quartz, from the Porcupine mine.

(d.) Galena with sphalerite, in quartz, from the Badger mine.

(e.) Magnetite, from Greenwater lake.—All from the district of Thunder bay, Ontario.

9. Selwyn, Dr. A. R. C. :

Auriferous quartz, from the Gladstone mine, township of Marmora, Hastings county, Ontario.

10. Smith, W. H. C. (Survey) :

Magnetite, from Big Turtle river, district of Rainy river, Ontario.

11. White, J. (Survey) :

(a.) Celestite, from lot 7, range X, of Bagot, Renfrew county, Ontario.

(b.) Moulding sand, from lot 3, range V, of north Sherbrooke, Lanark county, Ontario.

And the undermentioned constituted presentations :

1. Campbell, John, Nanaimo, British Columbia :

Limonite, from Texada island, British Columbia.

2. Chubbuck, C. E. D. Ottawa :

Phlogopite, from lot 13, range XV, of Hull, Ottawa county, province of Quebec,

3. Claxton, F. J., Victoria, British Columbia. :
Cinnabar ore, from Seshart channel, Barclay sound, Vancouver island. British Columbia.
4. Coughlin, D. :
Nickeliferous pyrrhotite, from lot 9, range VI, of Lorne, district of Algoma, Ontario.
5. DeWolf and Munro, Vancouver, British Columbia. :
 - (a.) Pottery clay, from Guichon creek, Nicola river, British Columbia.
 - (b.) Specular iron, from the junction of Nicola and Coldwater rivers, British Columbia.
6. Davey, Capt. T. R., per W. F. Ferrier (Survey) :
From the Harvey Hill mines, Leeds township, Megantic county, Quebec. :
Chalcopyrite, twenty-five specimens.
Bornite, twelve specimens.
Chalcocite, eight specimens.
Molybdenite, three specimens.
7. Firth, W., per R. G. McConnell (Survey) :
Vivianite, from the 'Ramparts,' Porcupine river, Yukon district.
8. Hammond, H. C., Winnipeg, Manitoba, per Dr. G. M. Dawson (Survey) :
Argentiferous galena, from Vermont creek, McMurdo district, East Kootanie, British Columbia.
9. Haycock, E. B., Ottawa :
 - (a.) Phlogopite, with plant inclusion, from north half of lot 10, range V, of Hull, Ottawa county, province of Quebec.
 - (b.) Phlogopite, dressed sheet, from same locality as the preceding.
10. Laperrière, M., per N. J. Giroux (Survey) :
Picrolite, from lot 18, range IV, of Durham, Pontiac county, province of Quebec.
11. Mackay, J. W., per Dr. G. M. Dawson (Survey) :
Native copper, from above Stein creek, Fraser river, British Columbia.
12. McLellan, S. :
Phlogopite, from lots 11 and 12, range XVI, of Hull, Ottawa county, province of Quebec.

13. McCuaig, R. C. W., Ottawa :
Muscovite, from lots 4 and 5, range XI, of the township of Miller, Frontenac county, Ontario.
14. McRae, Hector, Ottawa :
 - (a.) Apatite in pyrite, from lot 11, range V of Templeton, Ottawa county, province of Quebec.
 - (b.) Core of garnetiferous granite, from boring at last mentioned locality.
15. Nellis, T. F., Ottawa :
 - (a.) Phlogopite with inclusions of albite, apatite, garnet and pyrite, from lot 10, range XII, of Hull, Ottawa county, province of Quebec.
 - (b.) Phlogopite with inclusion of molybdenite, from same locality as the last.
 - (c.) Phlogopite with inclusion of pyrite, from same locality as the two preceding.
16. Poole, H. S., Stellarton, Nova Scotia :
Sphalerite and chalcopyrite, from the Albion mines, Pictou county, Nova Scotia.
17. Röeser, F., Kootanie Smelting and Trading Syndicate, Revelstoke, British Columbia, per H. M. Ami (Survey) :
Ingot of argentiferous lead, smelted from ore from the Monarch claim, at the Revelstoke smelter.
18. Ryckman, S. S., M.P., Hamilton, and W. H. Scott, of Illecillewaet, British Columbia :
Argentiferous galena, from the Elizabeth claim, Fish river, West Kootanie district, British Columbia.
19. Smart, Capt. W. J., Montagu, Nova Scotia :
Auriferous quartz, from the Rose lead, Montagu mine, Halifax county, Nova Scotia.
20. Soues, F., Clinton, British Columbia, per Dr. G. M. Dawson (Survey) :
Native gold, from the Bonanza claim, Cayoosh creek, near Lillooet, British Columbia.
21. Sperry, F. E., Sudbury, Ontario, per A. E. Barlow (Survey) :
Polydymite, from the Vermilion mine, lot 6, range IV, of Denison, district of Algoma, Ontario.

22. Warmington Stone and Marble Company, Garden River, Ontario:

- (a.) Limestone polished, from Echo lake, district of Algoma, Ontario.
- (b.) Limestone polished, from Garden River, district of Algoma, Ontario.

"Mr. C. W. Willimott has, for the most part, been engaged in making up collections of minerals and rocks for various educational institutions. The following is a list of those to which such collections have been sent:—

1.	St. Mary's Academy, Windsor, Ont..	Consisting of 103 specimens.			
2.	City Museum, Vancouver, B.C....	do	106	do	
3.	Collegiate Institute, Napanee, Ont.	do	106	do	
4.	Protestant Board of School Com- missioners, P.Q.....	do	106	do	
5.	College of Hull, Hull, P.Q	do	96	do	
6.	Elgin Street School, Ottawa, Ont..	do	96	do	
7.	Model School, Windsor Mills, P.Q.	do	108	do	
8.	Upper Canada College, Toronto... .	do	108	do	
9.	Waterville Model School, Water- ville, P.Q.....	do	108	do	
10.	Public School, St. Stephen, N.B... .	do	96	do	
11.	do St. Lambert, P.Q ..	do	91	do	
12.	Preston Mechanics' Institute, Pres- ton, Ont.....	do	96	do	
13.	St. Patrick's High School, Halifax, N.S.,.....	do	96	do	
14.	Legislative Assembly, Winnipeg, Man.....	do	108	do	
15.	High School, Bowmanville, Ont... .	do	106	do	
16.	do Oshawa, Ont.....	do	91	do	
17.	do (Victoria), Moncton, N.B.....	do	108	do	
18.	Panet Street School, Montreal, P.Q.	do	91	do	
19.	Mount Allison University, Sackville, N.B.....	do	145	do	
20.	Bathurst Village School, Bathurst, N.B.....	do	108	do	
21.	Central School, Brantford, Ont....	do	108	do	
22.	Lunenburg County Academy, Lun- enburg, N.S.....	do	108	do	

" The following collections are in course of preparation for, and will shortly be sent to, the undermentioned institutions :—

1.	Collegiate Institute, Morrisburg, Ont.	consisting of 108 specimens.				
2.	do	Peterborough, Ont	do	108	do	
3.	School of Practical Science, Toronto,					
	Ont.	.....	do	108	do	
4.	Morrin College, Quebec, P.Q.	.....	do	108	do	
5.	High School, St. George, N.B.	.....	do	108	do	
6.	do	Georgetown, Ont.	do	108	do	
7.	Central School, Moncton, N.B.	.....	do	108	do	

" A collection of two hundred and fifty specimens, sent by the College of St. Laurent, Montreal, for identification, was named and returned.

" In the course of the summer months Mr. Willimott visited—with the object of procuring further material for the making up of collections, and cabinet specimens for the Museum—the townships of Buckingham, Hull, Low, Masham, Portland, Templeton, Villeneuve and Wakefield, in Ottawa county, province of Quebec; those of Bromley, Brudenell, Ross and Sebastopol, in Renfrew county, and that of Cameron, district of Nipissing, in the province of Ontario.

" In the prosecution of this work he has succeeded in collecting a large and varied assortment of minerals, and at the same time made many interesting and useful observations in regard to their mode of occurrence. The collection comprised :—

	Specimens.
Albite, massive.....	50
Albite, crystals.....	15
Albite with smoky quartz, fluorite and amazon-stone	25
Apatite, crystals.....	230
Apatite in calcite.....	36
Biotite.....	44
Fluorite with albite and sphene	50
Fluorite with amazon-stone	40
Graphite.....	48
Gummite.....	12
Hornblende, groups of crystals.....	20
Hornblende with tremolite.....	96
Microcline, massive.....	60
Microcline, crystals.....	8
Mountain cork.....	20
Muscovite.....	75

	Specimens.
Orthoclase, groups of crystals	75
Phlogopite.....	45
Phlogopite, crystal.....	1
Pyrite with pyrrhotite	110
Pyroxene, crystals.....	300
Pyroxene, groups of crystals	50
Quartz.....	35
Quartz, groups of crystals.....	50
Scapolite, crystals.....	6
Scapolite, groups of crystals.....	60
Spessartite.....	50
Sphene, crystals	30
Sphene in calcite.....	20
Tourmaline, crystals.....	17
Tourmaline in albite.....	88
Uraninite (diss.).....	36
Wollastonite in calcite	50
Miscellaneous associations	30
Three minerals (under examination) represented by.....	77
Total number of specimens collected ..	2,039
Galena from Bedford (applied for).....	300 lbs.

"The foregoing include very many handsome cabinet specimens, the most conspicuous amongst which are some white and reddish crystals of albite; crystals of black tourmaline; fine specimens of spessartite; crystals of Wollastonite in sky-blue calcite, one some two inches in length and a little over one inch in breadth and well terminated; a crystal of phlogopite, fifteen inches and a-half long, three inches and a-half diameter at the top, four inches and a-half diameter at the centre, and weighing some fifteen pounds; also a very handsome group of crystals of microcline."

Mr. W. F. Ferrier, lithologist, reports that during the year, as in 1890, he has been engaged in the study, arrangement and classification of the stratigraphical collection of rocks. Early in the year new cardboard trays were ordered to fit the drawers under the flat cases devoted to this collection. Thirty-nine of these drawers were gone over, the specimens cleaned and provisionally arranged in the new trays,

worthless material was rejected and three boxes of duplicates were carefully labelled and placed in store. This work involved the handling of over 1,800 specimens. There are 141 more drawers, all the specimens in which will have to be similarly gone over before the best and most suitable series can be selected for the exhibition cases, and their systematic arrangement carried out.

Superintending the preparation of the rock sections required for the microscopical determination of the characters of the specimens also occupied considerable time; 142 such sections were prepared and studied during the year.

On the 21st of July Mr. Ferrier left Ottawa to make some lithological investigations in the Eastern Townships, more especially in Broughton and Leeds.

In the spring while examining the rocks collected by Mr. Webster in 1879, Mr. Ferrier had recognized in a specimen from lot 1, range VII of Marlow, a small fragment of scheelite or tungstate of lime. He therefore also visited this locality and succeeded in finding it in some quantity in quartz veins, cutting Cambrian slates, and accompanied by its decomposition product tungstate or tungstic acid. Galena, copper and iron pyrites, blonde and other minerals were also found in the veins.

On the 10th of August he returned to Ottawa and was occupied chiefly in microscopical work till the 30th of September when he again visited the locality, remaining there till the 8th of October. The tungsten minerals were found in nearly all the veins examined, but in some only in small quantity.

The best locality, apparently, is that from which the original specimen came, where they are rather abundant in the vein. Though little more than a foot wide at its outcrop, further development might reveal the tungsten ore in quantities sufficient to justify mining on this vein. No ore of tungsten had hitherto been recognized *in situ** in Canada. Its discovery is of interest at a time when so many experiments are being made with steel, in view of the remarkable and valuable properties possessed by tungsten steel.

Tungstic acid has also been used in calico printing to produce a yellow colour.

The discovery is also interesting in connection with the fact that scheelite is very commonly accompanied by ores of tin and that for several years past I have indicated this south-eastern portion of the province of Quebec as the district where this ore should be sought,

*Geology of Canada, 1863, p. 503.

and where, if anywhere in Canada, the search might prove successful. In Phillip's mineralogy it is stated: "This mineral (scheelite) occurs both crystalline and amorphous, particularly in the depositories of tin ore at Schlackenwald and Zinnwald, in Bohemia, and in Monroe county (Conn.), United States."

Mr. Ferrier collected many fine crystals of scheelite as well as large samples of the ore, for the museum. An analysis, by Mr. R. A. A. Johnstone under the supervision of Mr. Hoffmann, was made in the laboratory of the survey, and showed the scheelite to contain 79·9 per cent of tungstic acid, or within 7 per cent of the theoretical quantity.

The full analysis will appear in Mr. Hoffmann's report on the chemical work of the survey.

Since the 8th of October Mr. Ferrier was chiefly occupied in the examination of specimens collected during the summer by various members of the staff in order to ascertain their character by means of the microscope and blow-pipe. These examinations include a detailed report on specimens from Chateau Richer, Quebec, to accompany Mr. Low's report on work in that district, and also a microscopical examination of Huronian rocks from the Sudbury district collected by Mr. Barlow. This was being proceeded with at the close of the year. The cost of the season's work in the field was \$209.89.

PALÆONTOLOGY AND ZOOLOGY.

Mr. Whiteaves reports that the third part of the first volume of "Contributions to Canadian Palæontology" was published in May last. It consists of a systematic and descriptive report, of fifty-eight pages octavo, illustrated by six full page lithographic plates, on the fossils of the Devonian rocks of the Mackenzie River basin, for the most part collected by Mr. R. G. McConnell in the years 1887, 1888 and 1890. A full suite of the specimens to which it refers has been placed on exhibition in the museum, and such duplicates as remain have been labelled for distribution to educational institutions in Canada.

A paper on "the Orthoceratidæ of the Trenton Limestone of the Winnipeg basin" has been written for the Transactions of the Royal Society of Canada, and is now printed in the volume for the current year. This paper consists of 10 pages quarto, illustrated by seven full page lithographic plates.

During the past year, also, three descriptive and illustrated papers on purely palæontological subjects have been written for and printed

in the "Canadian Record of Science." The first of these, which is entitled "Descriptions of Four New Species of Fossils from the Silurian Rocks of the South Eastern Portion of the district of Saskatchewan," was published in the April number of the "Record," and consists of eleven pages octavo of letter press, illustrated by one full page lithographic plate. The second, which, with the third, was published in the October number of the "Record," consists of a description of a large new species of *Panenka* from the Corniferous limestone of St. Mary's, Ontario, and is illustrated by one full page lithographic plate. The third is a note "on the Occurrence of Paucispiral Opercula of Gasteropoda in the Guelph formation of Ontario," and is illustrated by one woodcut.

The third part of the "Contributions to Canadian Micro-Palaeontology," by Professor T. Rupert Jones, F.R.S., referred to in the last annual report as having been received in MSS., was published in August. It consists of forty-two pages of text, illustrated by four full page lithographic plates.

It has been decided to devote the second volume of the "Contributions to Canadian Palaeontology" to an illustrated monograph on "Canadian Fossil Insects," which Professor S. Scudder, of Cambridge, Mass., the most experienced authority on this subject in America, has kindly promised to prepare. The first part of this volume, consisting of a paper, of twenty-six pages large octavo, and illustrated by one full page lithographic plate, "on the Tertiary Hemiptera of British Columbia," was published last April, and the second part is now nearly ready for the printer.

The manuscript of a considerable portion of the fourth part of the first volume of the "Contributions to Canadian Palaeontology" has been written and eight of the lithographic plates required to illustrate it have been printed off. As stated last year, this report, when complete, will consist of a descriptive and systematic report on the unusually large collections of fossils made by Mr. Tyrrell in 1888 and 1889 from the Devonian rocks of lakes Manitoba and Winnipegosis. That part of the letter press which is now nearly ready for the printer consists of descriptions or identifications, as the case may be, of the whole of the species of sponges, corals, echinodermata, vermes, polypozoa, brachiopoda and of part of the pelecypoda, represented in those collections, and it is hoped that the whole report will be ready for publication in the spring. The Stromatoporoids in these collections have already been kindly reported upon by Professor H. Alleyne Nicholson, of the University of Aberdeen, in a paper in the Annals and Magazine of Natural History (London, England) for April, 1891, in which the species are described and figured.

Since the systematic "List of the Fossils of the Hamilton Formation of Ontario" was published in 1887, in the second part of the first volume of "Contributions to Canadian Palæontology," so many additional species from that formation have been received and so much new information about its fauna has been obtained, that it is thought desirable to publish a supplement to this list at an early date. With a view of making this supplement as complete as possible, about a week last summer was spent in an examination of all the exposures of the Hamilton formation near Thedford and Arkona and in a study of the fossils obtained therefrom during the past four years by the Rev. Hector Currie, of Thedford. Some interesting additions to this local fauna were thus made, and the writer is greatly indebted to Mr. Currie for his courtesy on this, as on a previous and similar occasion, and for the loan of some of the rarest specimens of fossils from his cabinet.

In Zoology, an important collection of the mammalia, birds and reptiles of the Rocky Mountain park, and a series of about 175 specimens of birds and small mammalia from Indian Head, Assiniboia, have been received during the year from Professor Macoun. A few interesting additions have been made to the zoological collections in the museum through Dr. G. M. Dawson, in connection with the British Behring Sea Commission, being chiefly donations from various gentlemen, or purchased as noted elsewhere. These include the skin and skull of a Pacific walrus, the skeleton of an adult male fur seal, some bones of the extinct *Rhytina* of Behring Island, a specimen of the sooty albatross from the coast of British Columbia, &c.

Besides a few birds which have been put up as skins, nine specimens of Canadian mammalia, one hundred and six specimens of birds, and one turtle, have been skilfully mounted during the past year, by Mr. S. Herring, the taxidermist to the survey, but most of these are intended for the museum which it is proposed to establish in the Rocky Mountain park at Banff. Among the more interesting specimens of native mammalia recently added to the survey museum, and not already enumerated, are a Rocky Mountain sheep, a fine example each of the "fisher" and cross fox, both from Norway House, and presented by Mr. Horace Belanger, and a yellow-haired porcupine from Illicil-lewaet.

During the director's absence from the city, on field work, the duties of acting director have, as usual, devolved upon Mr. Whiteaves, and, in addition to the correspondence entailed thereby, 263 official letters have been received during the year and 227 written.

Mr. Weston reports that, with the exception of one month spent in field work, the whole of his time, from the 15th of January up to the

end of the year, has been occupied in work in the palæontological and archæological branches of the museum, in the rearrangement of specimens and the incorporation of new ones into the collection, in the writing of labels, in making improvements in the contents of many of the glass cases, in the preparation of fossils either for study or for exhibition in the museum, in the making of microscopic sections of rocks and fossils, and in other office work. From the 1st to the 27th of July he was engaged in the examination of various rocks in the city of Quebec, on the north shore of the Island of Orleans and along the north shore of the St. Lawrence between the mouth of the St. Charles river and St. Joachim. At each of these localities interesting collections of fossils were obtained, some of which will, it is expected, throw additional light on the stratigraphical relations of the rocks from which they were obtained. Among these fossils are a large series from the Hudson River formation along the north shore of the Island of Orleans, and a fine collection from the Utica slate in the vicinity of the mouth of the St. Charles river.

Mr. H. M. Ami reports that during the past year, with the exception of two months spent in the field, he has been employed in the examination and determination of the species in various collections of fossils made by members of the staff. He has completed the examination and comparison of some graptolites from the graphite-bearing slates of St. John, New Brunswick, and has made a list of fossils from an outcrop of Silurian rocks, on the east branch of the River Philip, Cumberland county, Nova Scotia, recognized by Mr. Scott Barlow in 1876. It lies sixteen miles to the west from the outcrop of the same formation at Wentworth, on the Intercolonial railway. For Mr. A. Low he has identified and prepared lists of the species in four collections from the Trenton limestone below St. Alban, above and below St. Casimir, and on River Charlotte, P.Q. He has also examined a small collection of graptolites from Côte Sauvageau, near Quebec city, and has prepared lists, for publication in Dr. Ells's report, of fossils from Philipsburg, St. Armand, Mystic, Stanbridge, Lake Memphremagog, and other localities in the province of Quebec, that were collected in 1890 by Dr. Ells and Messrs. Whiteaves and Deeks. The specimens examined from these well-known Cambro-Silurian localities were about 1,300. A preliminary examination has been made by him of about 500 specimens of fossils, collected by Mr. Giroux in the counties of Joliette, Berthier and Maskinongé, with a view of revising the boundaries of the Chazy and Trenton formations in those districts. Miscellaneous collections of fossils from Ontario, Quebec and Nova Scotia, made in past years by Messrs. Weston, McInnes, A. Ogden,

and H. Fletcher, from rocks of Cambro-Silurian and Silurian age have been examined and lists of the species prepared.

Some progress has been made in making up collections from the duplicate specimens in the museum, for distribution. Specimens have been sent to Mr. G. F. Matthew, St. John, N.B., and to Col. Grant and Mr. Wm. Turnbull, of Hamilton, in exchange for specimens received from them. Suitable collections of fossils are being prepared for the University of Toronto, the University of Fredericton, for Acadia College, Wolfville, N.S., and for other educational institutions. He has examined and, so far as their condition permitted, named, for the Rev. J. Carrière, principal of St. Laurent College, a miscellaneous collection of fossils, ranging from the Cambrian to the Cretaceous. Labels have been prepared, to be printed, for specimens in the museum from the Trenton, Devonian and Post Pliocene formations. He assisted in reading and correcting the proofs and revises of a palæontological publication prepared for the Survey, by Professor Rupert Jones.

From the 17th of July to the 15th of September Mr. Ami was occupied in field work, chiefly on and in proximity to the line of the Pacific railway in the Selkirks from Revelstoke eastward to Beaver Mouth and Donald, and thence to the summit of the Rocky mountains east of Field. He carefully examined the natural exposures and rock cuttings between Revelstoke and the summit of the Selkirks, but was as unsuccessful in finding fossils in these rocks as Dr. Selwyn and Dr. Dawson had been when they examined them in 1890.

Between Beaver Mouth and Donald, two miles west of the latter, the numerous exposures were likewise carefully examined and in these he succeeded in finding an abundant fauna; crustaceans, pteropods and brachiopods; the genera, *Olenellus*, *Agnostus* and *Hyolithes* were noticed, thus confirming the supposed Lower Cambrian age of these rocks. East of Donald, at the Glenogle slate and flag quarries, between Palliser and Golden, an interesting collection was made of the graptolites of that locality. At Field the trilobite beds on the western flank of Mount Stephen were visited, and an interesting collection made, containing about 25 species and 500 specimens of the Middle Cambrian fauna, first discovered in Mt. Stephen by Mr. McConnell.* At Anthracite, near Banff, about 100 specimens of fossil plants were collected from the Cretaceous rocks of that vicinity.

Besides the foregoing examinations Mr. Ami reports having ascended Moose creek, the south branch of the Illecillewaet for two miles and that the only rocks seen were dark coloured argillites inclined at a high angle. On the 10th of July, with a view to finding the contact of the gneissic rocks with the newer overlying series of the Illecillewaet

valley, he left the railway five miles above Illecillewaet and ascended the Flat creek trail seven miles to the summit. He then descended by Slick creek and Jeopardy slide five miles into the Fish river valley. One day was spent in the Fish river valley and the exposures for four miles down on the left bank to the mouth of Granite creek were examined. Granite creek was ascended for about one mile, to about 1,500 feet above Fish river, at which elevation massive granite occurs and apparently extends to the summit of the range. Specimens of all the rocks here seen were collected, and also samples from a vein of argentiferous galena then recently discovered and on which some 18 claims had been registered. On the 12th of July, he returned to Illecillewaet. The next day Corbyn trail was ascended to the summit of the range between the Illecillewaet and the North Fork, and specimens of the rocks were collected.

Five specimens of the galena above referred to have been assayed in the laboratory of the survey, giving 108·6, 109·3, 149·9, 175·7 and 204·1 ozs. to the ton of 2,000 lbs. and about 80 per cent of metallic lead.

Mr. Lambe reports that during the first half of the year he was engaged in a study of the large collections of fossils made by Messrs. Tyrrell and Dowling from the Devonian rocks of Lakes Manitoba and Winnipegosis in 1888 and 1889, assisting in their identification and determination. He has prepared drawings of a large number of the species of sponges, corals, polyzoa, brachiopoda, pelecypoda and gasteropoda contained in these collections, which, with the exception of those of the gasteropoda, have been already lithographed on stone and the entire issue of 1,100 copies printed, forming plates 33, 34, 35, 36, 37, 38, 39 and 40 for the Contributions to Canadian Palaeontology, vol. i, pt. iv. (Shortly to appear.)

During the latter half of the year he was occupied in an examination of the Orthoceratidae from the Trenton rocks of Lake Winnipegosis, assisting Mr. Whiteaves in their identification and determination. He has prepared drawings of these fossils, which form part of collections made by Mr. Weston in 1884, by Mr. Tyrrell in 1889, and by Messrs. Dowling and Lambe in 1890, reproductions of which appear in plates 5, 6, 7, 8, 9, 10 and 11 of the Transactions of the Royal Society of Canada for 1891 (now in the printers' hands) illustrating Mr. Whiteaves' paper on the Trenton Orthoceratidae of Manitoba, &c.

He has begun a classification of collections of fossils recently made from Lake Winnipeg, and has made a number of drawings for the better illustration of *Edrioaster Bigsbyi*, Bill.; *Amygdalocystites floralis*, Bill.; and *Pleurocystites filiteatus*, Bill., from the Trenton rocks at

* Annual Rep. Geol. Survey, 1886, Part D.

Ottawa. During the month of January, he was engaged in an examination of some fossils collected by Mr. McConnell in the Athabasca river, in 1890, and in preparing drawings for their illustration. These are published, in plate 32 of the Contributions to Canadian Palæontology, vol. 1, pt. iii. He has devoted some time to the examination of the fossils described in the papers published by Mr. Whiteaves in the Canadian Record of Science for April and October, referred to on p. 49 of this report, and has made all the drawings that are reproduced to accompany these papers.

In August he visited Peterborough, Woodstock and St. Mary's, Ont., and made collections of fossils from the exposures of Trenton limestone in the former place and from the Corniferous rocks of the latter, and later, in October, he spent a few days with Dr. Ells, in the vicinity of L'Orignal and Hawkesbury, Ont., collecting fossils from the Trenton and Chazy rocks near these localities.

The following is a list of specimens collected by officers of the survey during the past year, or presented to its museum through them :—

Dr. G. M. Dawson :

Specimens obtained in connection with the Behring Sea Commission, as under :—

Eight Haida (Queen Charlotte Island) trumpets and whistles, and one castanet.—Purchased.

One pair snowshoes, King's Island, Oke-eogmut tribe, Eskimo.
One bird snare made of whalebone, Kotzebue Sound, Eskimo.
Net, Kotzebue Sound, Eskimo.
Skin of Pacific walrus, from Behring Strait.

Presented by Capt.
M. A. Healy.

One pair snowshoes, Nunivak Island, Behring Sea, Magemut tribe, Eskimo.
One bird-dart, Nunivak Island, Magemut tribe, Eskimo.

Presented by Capt.
Hadley, H.M.S.
"Pheasant."

Specimens of Sponges and Sertularians from various localities.

One skull of the Pacific walrus (*Odobænus obesus*), from Kamtschatka.—Purchased.

Seal and sea otter spear, and throwing stick for same, Atka Island, Aleut.—Purchased.

Sixteen skins of birds from Behring Sea.—Collected by J. M. Macoun.

Four skins of birds from Behring Island.
Bones of *Rhytina Stelleri*.
Skeleton of male fur seal.

Presented by
Mr. N. Grebnitzky.

Skull of *Rhytina*, from Behring Island.—Purchased.

Several specimens of *Velutina coriacea* from St. Paul's island.

J. F. Whiteaves :—

A number of specimens of fossils from the Hamilton formation near Thedford and Arkona, Ont.

Prof. Macoun :—

About fifty specimens of fossils from the Lower Carboniferous rocks of the Rocky Mountain park, Alberta.

R. W. Ells & W. E. Deeks :—

About 1,000 specimens of fossils from various localities in the counties of Missisquoi, St. John, Laval, St. Hyacinthe, Bagot and Iberville, in the province of Quebec, and Russell and Prescott, in the province of Ontario.

R. G. McConnell :—

Twenty fossils from the Cretaceous rocks of the foot-hills of the Rocky mountains.

J. B. Tyrrell :—

Head of caribou (*Rangifer Caribou*) from Hole river, Manitoba.

T. C. Weston :—

About 250 specimens of fossils from various localities along the north shore of the St. Lawrence, between Quebec city and Cape Tourmente, also on the Island of Orleans.

L. M. Lambe :—

200 specimens of fossils from the Trenton and Chazy limestone at Peterborough, L'Orignal and Hawkesbury, and about 100 from the Corniferous limestone of Woodstock and St. Mary's, Ont.

A. P. Low :—

About seventy-five fossils from the Trenton and Black River limestone of Jacques Cartier county, P.Q., also twenty specimens of Post-Tertiary fossils from the same district.

R. Chalmers :—

A number of specimens of four species of fossils from excavations in marine alluvium at the west end of the Chignecto ship railway, at the head of the Bay of Fundy, and fossil wood of two species of trees from New Brunswick.

Numerous examples of twelve or more species of fossils from the Leda Clay and interglacial beds at Duck Cove and Negrotown Point, Lancaster, St. John county, N.B.

H. M. Ami :—

About 600 specimens of fossils from the Selkirk and Rocky mountain ranges, along the line of the Canadian Pacific railway.

Specimen of the yellow-haired porcupine (*Erethizon dorsatus* var. *epixanthus*), from Corbyns' trail on the Illecillewaet.

N. J. Giroux :—

About 500 specimens of fossils from the Cambro-Silurian rocks at numerous localities in the counties of Joliette, Berthier and Maskinongé, in the province of Quebec.

D. B. Dowling :—

About 500 specimens of fossils from the Cambro-Silurian and Silurian rocks of the west shore of Lake Winnipeg and islands adjacent thereto.

A few Indian implements and small pieces of pottery from the mouth of the Little Saskatchewan river, Manitoba.

J. McEvoy :—

Ten fossils from the Carboniferous limestone of White valley, Okanagan valley, B.C.

James Macoun :—

Twenty-five specimens of fossil plants from Hastings, near Vancouver, B.C.

The additions to the palæontological, ethnological and zoological collections in the museum, by presentation, exchange or purchase, are as follows :—

By presentation :—

Horace Belanger, chief factor Hudson's Bay Co., Norway House :—

Fine specimen each of the fisher (*Mustela Pennantii*) and cross fox (*Vulpes vulgaris* var. *decussatus*) from the Nelson river, Keewatin.

Patrick Neville (Deputy Inspector of Mines, N.S.), Bridgeport, C. B. :—

Thirty-three fine slabs of fossil plants from the Sydney coal field, and a lower jaw of a walrus from Cape Breton.

William Maddin (Deputy Inspector of Mines, N. S.), Westville, N. S. :—

Thirty specimens of fossil plants from the Springhill coal mines, N. S.

- H. S. Poole, Stellarton, N. S. :—
Thirty specimens of fossil plants from the coal mines near Stellarton.
- James Robertson, Albert Mines, Albert county, N. B. :—
Twenty-five specimens of two species of fishes (*Rhadinichthys*) from the Albert mines.
- J. W. Tyrrell, C.E., Weston, Ont. :—
Eskimo mittens and boots of seal skin, the latter with water-proof feet; Eskimo boots, waterproof; Eskimo boots, harp-seal skin, with feet of the skin of the square-flipper seal; and Eskimo slippers; all from North Bluff, Hudson Strait.
- J. B. Tyrrell, Geol. Survey, Ottawa :—
Cree-Stony Indian saddle from Wolf creek, Alberta.
- Hyacinthe Proulx, Ottawa :—
Stone gouge found near the Rideau river, Carleton county, Ont.
- Frank Butler, Ottawa :—
Hunter's knife and pipe-bowl from Alberta, used by Blood Indians of the Blackfeet tribe.
- John F. Fenton, Huntley, Carleton county, Ont. :—
Indian stone implement of singular and unusual shape, found by donor on his own farm, con. 3, lot 8, Huntley.
- Martin Griffin, jun., Ottawa :—
Egg of wood peewee (*Contopus virens*).
- J. D. Moore, St. Mary's, Ont. :—
Specimen of *Orthoceras* from the Corniferous limestone of St. Mary's.
- Prof. Henry M. Seely, Middleborough College, Middleborough, Vt.:—
One species of fossil from the Cambrian, two from the Calciferous, and two from the Chazy of the states of Vermont and New York.
- Prof. F. Schmidt, St. Petersburg, Russia :—
Nine species of fossils from the Cambrian and Silurian rocks of Estland and the Baltic.
- Alfred Ogden, House of Commons, Ottawa :—
Twenty specimens of fossils from the Trenton limestone at Rochesterville, Ont.

By Purchase :

From J. Stewart, Ottawa :—

Thirty-three rare or unusually perfect specimens of fossils
from the Trenton limestone, near Ottawa.

Rev. G. W. Taylor, Victoria, V.I. :—

Specimen of an undescribed decapod crustacean from the
Cretaceous rocks of Vancouver island.

BOTANY, &c.

In the last Summary Report on the work of this division it is stated that Professor Macoun was occupied on Part VI. of the Catalogue of Canadian Plants, and on the Catalogue of Canadian Birds. Part VI. has been completed, more than one-third of it has been printed, and the completed Catalogue of Canadian Birds will be ready for the printer before the end of the present month.

As these works are the result of the observation and collections of more than thirty years, it is hoped they will be well received, and prove useful to botanists and ornithologists throughout the world.

On the further work of this division during the year, Professor Macoun reports :—

“ In compliance with your suggestion, that I should undertake the preparation of a Catalogue of Canadian fungi, with special reference to the edible and to the poisonous species, I have been working at it at intervals during the past six years. I now know nearly 800 species of Canadian Fungi, and during the coming summer hope to be able to gather enough material to enable me to write up the whole subject next winter.

“ The agarics, which include most of the edible and poisonous fungi, change so rapidly after being gathered that drawings must be made from the fresh plant, and it is desirable that some arrangement be made to get this done during next spring and summer. During the month of September last large collections were made in the vicinity of Ottawa of these species, and Mr. Lambe made water-colour drawings of them in the evenings. He did the work remarkably well, and I would respectfully suggest that a small sum be placed in the estimates to remunerate him for this work in the past and for the prospective work of next spring and summer. I may say that unless an arrangement is made with some person in Ottawa to make the drawings, I can proceed no further with this desirable and useful work.

"Having completed the collection of material for the Catalogue of Birds, I am now gathering data for a Catalogue of Canadian fresh-water Fishes, and should like you to authorize me to prosecute that work as a supplement to my other work when in the field.

"Early last May you requested me to endeavour to complete the set of photographs of Canadian trees, and about the last of that month I went to the Niagara district where I knew there were many rare and well-grown specimens. I was not disappointed, and in the course of a little over two weeks forty very fine trees were selected, of which Mr. Topley took excellent photographs. My time being limited, I had to return to Ottawa before good specimens of all the western trees could be selected, as I had been requested by you to proceed to Banff in order to make a collection of specimens of the fauna and flora of the Rocky Mountain park and vicinity for the museum proposed to be established at Banff.

"About the 1st of May, I telegraphed to Victoria, to Mr. William Spreadborough, who had been with me two years in British Columbia, to come to Banff and commence making a collection of the birds and mammals. He reached Banff on the 7th of May and at once commenced work. He was very successful and had obtained 251 skins before I joined him.

"On the 20th of June I left Ottawa and reached Banff on the 25th, commencing work the same day. From that date to the 24th of August, I was continuously employed collecting and drying plants, and in making notes on the flora and fauna of the park. These notes have been put into order since my return, so that should a report on the natural history of the park be at any time required it can be written in a very short time. During the two months I spent at Banff and in its vicinity I collected over 1,000 species of plants, and since my return have examined and arranged them all. Most of these have been mounted, labelled, and placed in a cabinet made for their reception.

"Early in May, at your request, I instructed the taxidermist to commence setting up birds for the Banff musuem, and as far as I am aware he has been at that work ever since.

"The avi-fauna of the Rocky Mountain park will be found to consist of about 150 species, but it seems desirable that all the waders, swimming birds and grouse of the prairie region should be included in the collection, as nearly all travellers are sportsmen and they should be enabled to see for themselves the great variety of game birds that inhabit the Canadian prairies.

"A few small mammals and all the species of fishes known to be in the waters of the park were obtained. The skins of the larger fishes

were brought to Ottawa, and numerous entire specimens of the small minnow that lives in the warm water of the sulphur springs. That it does live in the warm water is undoubted, but it also lives in cold water and there attains a larger size. We traced it from the warm springs through pools of water in the tufa mounds below them to the marshes on a level with the Bow river. We saw none in the river, but it may be there nevertheless. The chief peculiarity about this fish is its large pectoral fins—very large in proportion to its size.

“Knowing that the Catalogue of Canadian Birds would likely be printed this winter, I and Mr. Spreadborough went from Banff to Indian Head, a locality peculiarly well suited for collecting the birds of the prairie region. After three days I came on to Ottawa, while Mr. Spreadborough remained there collecting for four weeks. The result was 152 skins of birds and small mammals, and a list of all the birds found in September in that district.

“Since my return to Ottawa, I have been busy—when not engaged on either of the catalogues above mentioned, on the routine work connected with the Natural History branch. This work is greatly hampered by the very insufficient accommodation afforded for its prosecution. You are aware that for three years this has been obvious, and though the attention of the Department of Public Works has been called to it repeatedly, nothing has yet been done to remedy it.

“It was intended that Mr. Jas. M. Macoun should accompany me to Banff, but his appointment as secretary to Dr. G. M. Dawson, of the British Behring Sea Commissioners, made a change in plans necessary. After my departure for Banff Mr. J. M. Macoun continued the work upon which he had been engaged since the opening of spring, viz., collecting plants in the vicinity of Ottawa, the flora of eastern Ontario being but poorly represented in our herbarium. On the 1st of July he was appointed secretary to Dr. G. M. Dawson, Behring Sea Commissioner for Canada, and since that date he has done no work for this branch excepting after office hours. While in Behring sea he collected plants whenever an opportunity was afforded and brought back with him the most valuable collection of arctic and sub-arctic plants that has yet been received into our herbarium. Many new species have already been described and others have not yet been determined.

“Since his return to Ottawa on the 20th of October, his duties in connection with the commission have occupied him during the regular office hours. In the evenings and at other times he has continued the usual routine work in the Natural History branch, and has been completing the collection of plants intended for the Banff museum; in a

few weeks all work in connection with it will be finished. He has been, besides, engaged in examining and naming the various collections of flowering plants that were made during the summer, or that have been received from other collectors, and getting out the specimens to mount. Since the 20th of October, 1,711 sheets of specimens have been labelled and mounted.

"All work, except the mounting of specimens, in connection with the herbarium has, as in former years, been done by Mr. J. M. Macoun. During 1891, 5,378 sheets of specimens were mounted and placed in the herbarium, many more than during any previous year. Of these 4,490 are flowering plants and 888 are cryptogams. Of the flowering plants 1,943 are Canadian, 2,142 are European and 405 are from the United States.

"4,526 sheets of specimens were sent to public institutions and to private individuals in exchange for desiderata. Of these 1,391 are cryptogams and 3,135 are flowering plants. Of the above total 1,823 specimens were presented to the following American and European institutions:—

British Museum.....	212
Central Experimental Farm	172
Department of Public Instruction, Quebec...	55
McGill University	100
National Museum, Washington.....	428
Harvard University.....	112
Shaw School of Botany, St. Louis.....	200
Columbia College.....	221
Michigan Agricultural College.....	183
Department of Agriculture, Washington	140

"Among the more valuable collections of plants received for the herbarium during the year may be mentioned those sent by J. A. Morten, Wingham, Ont., Jas. White, Edmonton, Ont., and Wm. Scott, Ottawa, and about 1,000 species presented to the herbarium by W. Bicknell, Bordighera, Italy. The last named is a remarkably fine and valuable collection, for which the special thanks of this Survey are due to Mr. Bicknell.

"Since the 31st of December, 1891, in connection with the work of this division, 429 letters of sufficient importance to copy were written and about the same number received."

MAPS.

Maps in course of Preparation and Published during 1891.

North-West Territory, 9 sheets, 20 to 26 inches long, by 16 inches broad, showing waters followed by the members of the Yukon Expedition, 1887-88, and reaching from longitude 111° to 144°, and latitude 59° to 68°, to accompany report by Mr. McConnell, published 1891.....	8 miles=1 inch.	
Index map of the above do do .	48 miles=1 inch.	
North-West Territory, Athabaska and part of British Columbia, to illustrate work of Mr. McConnell, 1889-90, and reaching from longitude 110° to 120° and lati- tude 54° to 60°, in draughtsman's hands	8 miles=1 inch.	
British Columbia, Kamloops sheet (Dr. Dawson) ready for publication.....	4 miles=1 inch.	sq. m. 6,400
British Columbia, Shuswap sheet (Dr. Dawson) in progress.....	do	6,400
British Columbia, Placer Mines of Cun- ningham Creek (Mr. Bowman).....	About 27½ chs=1 in.	34
British Columbia, Quartz veins and Placer Diggings, Grouse Creek (Mr. Bowman).	do 25 chs=1 in.	14
British Columbia, Placer Mines of Antler Creek (Mr. Bowman).....	do 26 chs=1 in.	38
British Columbia, Plan of Lightning Creek (Mr. Bowman).....	400 ft.=1 in.	17
British Columbia, Plan of Williams' Creek (Mr. Bowman)	About 10 chs=1 in.	12
The above (five) mining plans are in hand, and will shortly be ready for publication.		
Manitoba; Map showing the whole of Lake Winnipeg (Mr. Tyrrell) in progress....	4 miles=1 inch.	48,600
Northern Manitoba (part of) in progress (Mr. Tyrrell).....	2 miles=1 inch.	5,000
Northern Manitoba (Mr. Tyrrell) ready for publication	8 miles=1 inch.	20,000
Western Ontario, Lake of the Woods, sheet No. 2, ready for publication....	2 miles=1 inch.	2,000

Western Ontario (Hunter's Island sheet) sheet No. 7 (Dr. Lawson) ready for pub- lication.....	4 miles=1 inch.	3,456
Western Ontario, (north of Hunter's Is- land) sheet No. 6 (Mr. Smith) in pro- gress	do	3,456
Western Ontario, sheet No. 9 (Mr. Mc- Innes) in progress.	do	3,456
Ontario, sheet No. 130, Sudbury mining district (Dr. Bell) published with part F, Annual Report, vol. V., 1890-91....	do	3,456
Ontario, sheet No. 125, south of Sudbury sheet, in progress	do	(about) 1,800
do do No. 115, ready for draughts- man.....	do	3,456
do General map in progress.....	do	
Quebec, N.E. $\frac{1}{4}$ sheet (Eastern Townships map) ready for publication	do	4,500
Quebec, S.W. $\frac{1}{4}$ sheet (Eastern Townships map) in progress.	do	4,500
Quebec, N.W. $\frac{1}{4}$ sheet (Eastern Townships map) in progress.....	do	4,500
Quebec and Lake St. John district, $2\frac{1}{4}$ sheets in progress (Mr. Low)	do	6,912
Quebec, $\frac{1}{4}$ sheet, 18 S. E (Messrs. Bailey & McInnes), ready for engraver.....		3,456
Quebec, $\frac{1}{4}$ sheet, 18 N. E. (Messrs. Bailey & McInnes), in progress.....	do	(about) 500
Quebec, Lièvre River and Templeton phos- phate region, Ottawa county, 2 sheets (Mr. Ingall); sheet No. 2 engraved; sheet No. 1 ready for engraver.....	40 chns=1 inch.	220
New Brunswick, surface geology, $\frac{1}{4}$ sheets, 1 S.W., 1 S.E., and 1 N.E., 3 sheets (Mr. Chalmers), ready for publication .	4 miles=1 inch.	6,650
Nova Scotia, $\frac{1}{4}$ sheet, 11 N.W. in the en- graver's hands.....	do	
do $\frac{1}{4}$ sheet, 11 S.W. (Messrs. Fletcher & Faribault), published 1891.	do	(about) 650
Nova Scotia, $\frac{1}{4}$ sheets, 4 N.E. and 4 S.E. (Messrs. Fletcher & Faribault), in pro- gress.....	1 inch=1 mile.	

LIBRARY—SALES AND DISTRIBUTION OF PUBLICATIONS.

The librarian, Dr. Thorburn, reports that during the year, from the 2nd of January to the 31st of December, there have been distributed 8,593 publications of the Geological Survey Department, comprising annual reports, parts of these, special reports and maps. Of these, 5,918 were distributed in Canada; the remainder, 2,675, were sent to foreign countries as exchanges to scientific and literary institutions, and to a number of individuals engaged in scientific pursuits. In most cases, the institutions and individuals receiving the survey publications reciprocate by supplying the library with copies of their publications, or otherwise rendering important assistance in the work of the survey.

It may be stated that the general list of exchanges now amounts to 782, and, besides these, there are upwards of 1,000 others receiving reports on palaeontology, mineral statistics and botany. Due care has to be exercised in the distribution of the publications. Were all the applications granted, the supply, which is limited, would soon be exhausted. It is deemed advisable to retain a sufficient number in stock with which to supply future requirements. A large number of the earlier reports are already out of print, and can no longer be supplied.

The number of books, pamphlets and maps presented to the library last year was 2,307. Besides these, 146 books were purchased, and 38 periodicals, on geological, mineralogical and natural history subjects, were subscribed for.

The number of books bound in 1891 was 256.

The letters and acknowledgments sent to the library for publications distributed during the year were 1,952, and the number of letters sent out by the librarian was 1,053.

There are now about 9,000 volumes and 3,600 pamphlets in the library.

Attention is again called to the altogether insufficient space available for library purposes. The cases are all filled, and a large portion of the books are piled up round the library floor and in other parts of the building, and consequently, in many cases, it is difficult to find works which are required for consultation by members of the staff.

Sales of survey publications for the year ending 31st December, 1891, amounted to \$3,550.03.

VISITORS.

The number of visitors to the museum during the year was 20,363, being an increase of 2,063 over 1890, and of 10,814 since 1882, the first year of the opening of the museum in Ottawa.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The strength of the staff at present employed is 56, viz., professional, 37; ordinary, 19.

During the calendar year the following changes in the permanent staff have taken place:—

Mr. W. F. Ferrier, appointed lithologist.

Mr. N. J. Giroux do assistant geologist.

Mr. A. E. Barlow do do

Mr. S. Barlow, chief geographer, promoted to the rank of chief clerk.

Mr. H. P. Brumell, promoted from the third to the second class.

The amount available for the fiscal year ended 30th June, 1891, was:—

	Grant.	Expenditure.
	\$ cts.	\$ cts.
Civil list appropriation	47,330 00	
Geological Survey and Museum appropriation.....	60,100 00	
Artesian boring appropriation	10,000 00	
Civil list salaries		41,792 50
Wages of temporary employés.....		19,001 16
Exploration and survey		27,473 81
Boring operations, Deloraine, Man		6,514 48
Printing and lithography		9,605 39
Stationery, mapping materials and Queen's Printer.....		1,823 55
Purchase of specimens		309 40
Purchase of books and instruments.....		545 35
Purchase of laboratory apparatus and chemicals.....		508 05
Incidental and other expenses.		1,805 72
LESS—Paid in 1890.....		109,379 36 6,534 66
ADD—Advances to field explorers.....		102,844 70 5,159 75
Unexpended balance, civil list appropriation.....		5,537 50
do general do		3,888 05
	117,430 00	117,430 00

The correspondence of the department shows a total of 10,852 letters sent, and 6,947 received.

I have the honour to be, Sir,

Your most obedient servant,

ALFRED R. C. SELWYN,

Deputy Head and Director.

Geological Survey Department

HONOURABLE JOHN RICHARDSON MINISTER.

HONOURABLE SUGAR DEWDNEY, MINISTER

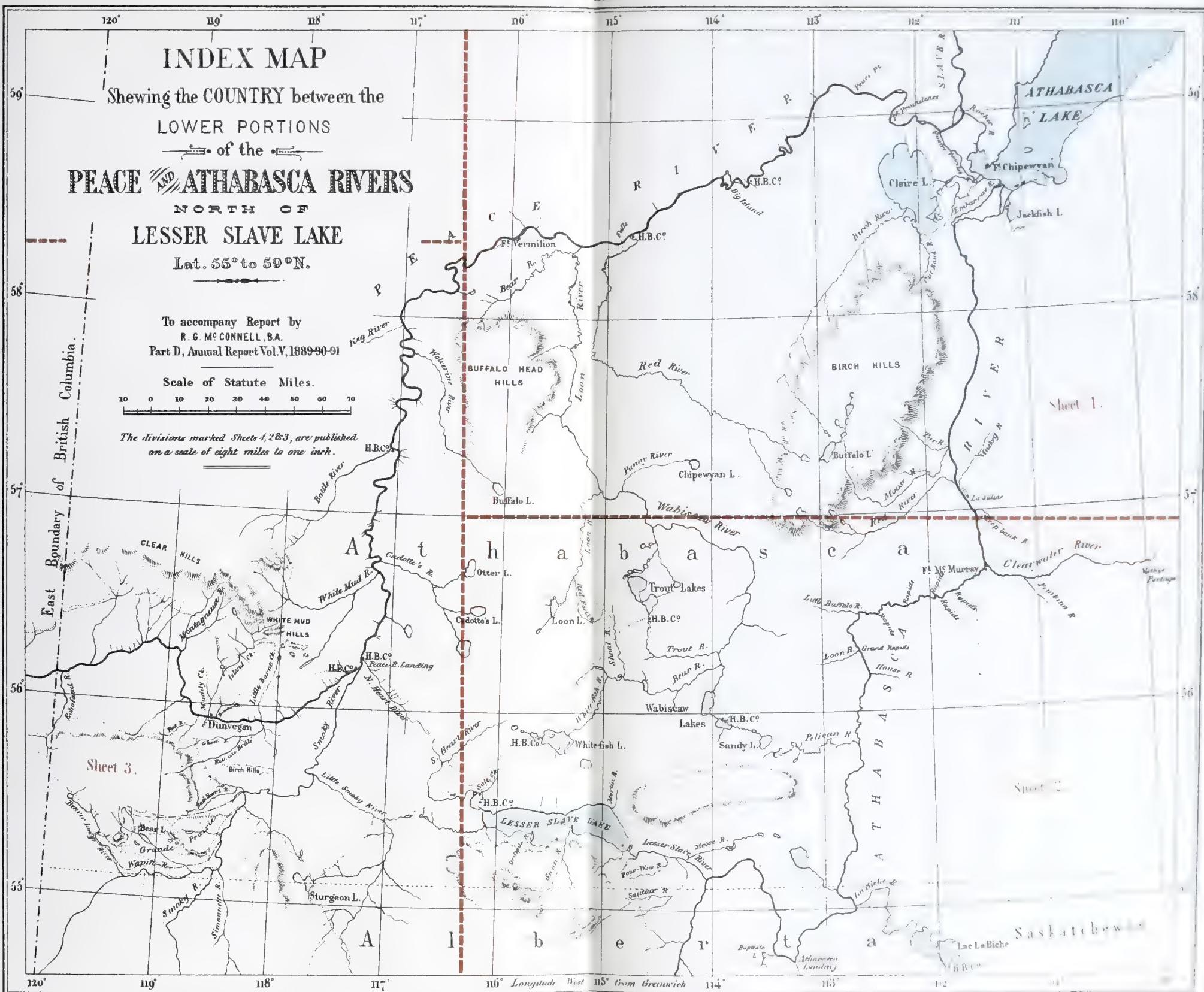
1802

INDEX MAP
Shewing the COUNTRY between the
LOWER PORTIONS
— of the —
PEACE AND ATHABASCA RIVERS
NORTH OF
LESSER SLAVE LAKE

To accompany Report by
R. G. McCONNELL, B.A.
Part D, Annual Report Vol.V, 1889-90-91

Scale of Statute Miles.

The divisions marked Sheets 1, 2 & 3, are published
on a scale of eight miles to one inch.



GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT
ON A PORTION OF THE
DISTRICT OF ATHABASCA
COMPRISING THE COUNTRY BETWEEN
PEACE RIVER AND ATHABASCA RIVER
NORTH OF LESSER SLAVE LAKE

BY

R. G. McCONNELL, B.A.



OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY.
1893



R. G. McConnell, Photo., August, 1890.

CLIFF ON TAR SANDS, ATHABASCA RIVER.

INTRODUCTORY.

PREVIOUS EXPLORATIONS, GENERAL PHYSICAL FEATURES AND AGRICULTURAL CAPABILITIES.

The history of the Peace and Athabasca country commences in 1778 when Peter Pond, subsequently a partner in the North-west Company, pushing north-westward in search of new fur districts, reached the Athabasca by way of Methy Portage and the Clearwater River, and descending it, founded a fort known as the "Old Establishment," about thirty miles above its mouth. In 1788, this post was abandoned and a new one built on the south shore of Lake Athabasca, on what is now known as "Old Fort Point." Still later, this site was also deserted and a better one selected on the north shore, near the outlet of the lake. A general map of the North-west was published by Peter Pond in 1785.

Peter Pond's travels.

Peter Pond's venture proved extremely remunerative, and he was followed by other traders who gradually spread themselves over the then unknown country to the north and west. A complete survey of the Athabasca appears to have been made by David Thomson.* This energetic but little known traveller made a track survey in 1799 of Lesser Slave River, and of the Athabasca from the mouth of the Pembina to Clearwater Forks. In 1803, he filled in the gap between the Forks and Lake Athabasca, and in 1810 ascended the river and crossed the Rockies by the Athabasca Pass, thus completing his traverse. Peace River was ascended and surveyed by Sir Alexander Mackenzie in 1792, from its mouth to a point about six miles above the Smoky River Forks, but a post had been established some years before, near the present site of Fort Vermilion. In 1793 he completed his journey and explored the river to its source.

David Thomson's surveys.

Mackenzie's journey.

The portion of the Athabasca between the Clearwater Forks and the lake was examined and briefly described by Franklin in 1819 and Other explorers 1825, and by Richardson in 1848, and as it formed part of the principal inland route to the Arctic Ocean, it was also travelled by Back, Simpson and other Arctic explorers. In 1843, Lefroy descended the Clearwater and the Athabasca River, and in 1844 ascended Peace River to Dunvegan, and then leaving the river travelled eastwards to

*Brief narrative of the journeys of David Thomson in North-western America, by J. B. Tyrrell, M.A., Proc. Can. Ins., 1887-88, vol. VI., p. 135.

Edmonton by Lesser Slave Lake. Lefroy observed for latitude and longitude and established the magnetic variation at a number of points along his route. In 1875, Dr. Selwyn, Director of the Geological Survey, mapped and reported on the upper part of Peace River, as far down as the mouth of Smoky River, and in the same year Professor Macoun, who accompanied him proceeded down the river to Lake Athabasca, and returned east by the usual Athabasca-Clearwater route, while Dr. Selwyn reascended Peace River, and returned by British Columbia.* In 1879, Dr. Dawson examined Pine River, Smoky River and other branches of Peace river. In 1883, W. T. Thompson, D.L.S., extended the regular instrumental surveys of the Dominion Lands Branch, Department of the Interior, into the Peace River country. In 1882, a track survey and geological examination of the Athabasca, below the mouth of Lake La Biche River, was made by Dr. R. Bell†, and finally, in 1884, a micrometer survey of the lower parts of both the Peace and Athabasca rivers, was made by Wm. Ogilvie, D.L.S.

Area of country.

The country between the Peace and Athabasca rivers north of Lesser Slave Lake, comprising an area of about 44,000 square miles, was not entered by any of the travellers referred to and remained entirely unknown until the present exploration was undertaken.

General description.

The greater part of this district may be described as a gently undulating wooded plain, diversified with numerous shallow lakes, muskegs and marshes. Small prairie patches, manifestly due to forest fires, occur north of the west end of Lesser Slave Lake, at several points along the Loon and Wabiscaw rivers, also on Peace River around Fort Vermilion and at other places, but their total area is relatively insignificant. The principal forest trees are the white and black spruces, *Picea alba* and *nigra*, the balsam-fir, *Abies balsamea*, the Banksian pine, *Pinus Banksiana*, the larch, *Larix Americana*, the aspen, *Populus tremuloides*, the balsam-poplar, *Populus balsamifera*, and the canoe birch *Betula papyracea*. The species of spruce occur along many of the river flats, and on the uplands they are found nearly everywhere except on the drier hills. The white spruce attains, in favourable localities, a diameter of two feet or more, but it is usually much smaller. It is the most valuable tree in the district. The Banksian pine grows thickly on the sandy and gravelly ridges, while the aspen prefers a loamy soil and characterizes the best agricultural parts of the country. The larch, balsam, balsam-poplar and birch, although found in every part of the district, are more scattered and

*Geological Survey of Canada, Report of Progress, 1875-76.

†Geological Survey of Canada, Report of Progress, 1882-3-4.

do not form continuous forests like the spruce, Banksian pine and aspen. On the lower part of the Wabiscaw and Loon rivers a large irregular branched, rough barked cottonwood was noticed, which is probably *Populus monilifera*.

The rolling plains between Peace River and the Athabasca are relieved by several high ridges or plateaus, all of which owe their origin to a differential denudation of the soft rocks on which the plains are based. Of these Marten Mountain is situated north-east of Lesser Slave Lake, above which it rises to a height of about 1,000 feet. The Buffalo Head Hills commence abruptly about fifty miles above the mouth of the Loon River, with an elevation of about 2,500 feet above the sea, and running in a south-south-westerly direction die away opposite the mouth of Battle River, while Birch Mountain extends for nearly ninety miles along the lower part of the Athabasca, from which it is separated by a plain fifteen to twenty miles wide. Among the smaller elevations are Trout Mountain, which is situated north of the Wabiscaw River, and the Thickwood Hills, which lie south of Birch Mountain. The uplands of the district, like the lowlands, are all wooded, and are dotted everywhere with lakes and marshes.

The principal watercourse of the district is the Wabiscaw-Loon River. This stream, with its numerous tributaries, drains nearly half the region. Among the other rivers are the Pelican, Red, Moose and Tar rivers, flowing into the Athabasca; Birch River draining into Lake Claire; and the Red, Wolverine and Cadotte's rivers are tributaries of Peace River. The main rivers branch in the interior of the district into a multitude of small winding streams, few of which have valleys of any size, and they usually flow in a sluggish manner, often expanding into lakes in the flat districts, but break over the steeper slopes of the country in a series of strong rapids. With the exception of the lower part of Loon River, none of these rivers are navigable by steamers.

A noticeable feature of the district reported on is the multitude of Lakes. lakes which occur everywhere, scattered over plains, plateaus and ridges. The lakes range in size from broad sheets of water twelve to fifteen miles in length, to small ponds a few feet across. They are usually shallow and weedy, and in many cases are being gradually filled up with *Sphagnum*. Many of the smaller lakes of former times have been completely filled up and are now represented by muskegs. The origin of most of the lakes is due to the numerous shallow depressions in the boulder-clay floor of the district, becoming filled with water; but in some instances they appear to have been caused by the damming up of some of the smaller streams by beavers.

Lake Claire, Lake Mammawee, and a number of other smaller lakes in the north-eastern part of the district, differ in origin from those just described, as they occupy part of the common delta-plain of the Peace and Athabasca rivers, which stretches from the west end of Lake Athabasca up both these streams for many miles. They represent portions of Lake Athabasca separated from the main basin by accumulations of stream detritus. These lakes are everywhere very shallow, their ordinary depth seldom exceeding nine feet, even in their deepest parts. In seasons of exceptionally high water, the low marshy plain separating them from the main lake, and from one another, is flooded, and they become re-united. Lake Claire is the largest of the group, being from ten to fifteen miles wide, and from twenty-five to thirty miles in length. The northern part of this lake has not yet been surveyed.

Agriculture.

The agricultural capabilities of portions of the Peace-Athabasca district are promising, but have not yet been thoroughly tested. Vegetables of various kinds are grown yearly without difficulty, at Fort Vermilion, Lesser Slave Lake, Whitefish Lake and Trout Lake, while potatoes are grown by Indians even on the summit of Birch Mountain, at a height of 2,300 feet above the sea. Wheat and other cereals have been fairly successful at Lesser Slave Lake and at Fort Vermilion, the only places where they have been tried. The prairie country around Fort Vermilion equals in fertility the famous Edmonton district and appears to enjoy an equally good climate, its higher latitude being compensated for by its more western situation, and by its lower elevation. This district is about 1,000 feet above the sea. In the interior, narrow strips of aspen-covered, but excellent land are usually found along the main rivers, and surrounding many of the lakes; and numerous areas, often equal in size to eastern counties, might be selected, which appear well adapted for cultivation, but the numerous swamps, muskegs and marshes, which separate these areas, detract greatly from their value. The western, and especially the north-western, portion of this district contains the most promising agricultural lands.

DESCRIPTION OF ROUTES.

Canoe traverse from the Athabasca River to Peace River by way of the Pelican, Wabiscaw and Loon Rivers.

Canoe traverse
from the Atha-
basca to the
Peace.

The field season of 1888 was commenced by making a canoe traverse across the unexplored country lying between Peace River and the Athabasca, by way of the Pelican, Wabiscaw and Loon rivers. The

length of this traverse from the mouth of the Pelican to the mouth of the Loon, is about 200 miles, measured in a straight line, but the distance actually travelled, following the winding courses of the various streams, amounted to nearly 400 miles, and occupied altogether about three weeks. Two portages, one of three miles Portages. and the other of two miles, occur on the route, and great care had to be exercised in descending the unknown Wabiscaw River with its numerous rapids, but with these exceptions, no especial difficulties were encountered.

The Pelican River empties into the Athabasca about 102 miles below Athabasca Landing. Its length, from its source in Pelican Lake to the Athabasca, is about twenty-seven miles, measured in a straight line, but fully twice this distance following the numerous windings of the stream. It has a total fall of 544 feet, the greater part of this descent occurring in the last five miles, where it breaks through the plateau down to the level of the Athabasca. The lower portion of the stream in which this rapid descent takes place is unnavigable, and the traverse began by making a disagreeable portage of three miles out of the valley of the Athabasca—which is here 350 feet deep—through aspen and spruce forests and across muskegs to a point on Pelican River above the rapids.

From the east end of the portage to Pelican Lake, Pelican River maintains a general westerly direction, it has an average width of fifty to sixty feet, its current, as a rule, is sluggish, but boulder bars forming short rapids occur frequently for the first ten miles, and occasionally all the way up.

It is exceedingly crooked, and in one place a portage of less than a mile, saved a detour reported to be ten or twelve miles.

The principal tributaries of Pelican River are: Muskeg River, which enters it from the north, and is fully equal in size to the main stream; and Crooked Neck River and Long Lake Creek, which join it from the south. The country adjoining the Pelican River is low and generally wooded, chiefly with spruce and aspen, but in places the river winds through wide marshy flats covered with wild hay. The flat country extends southward to Pelican Mountain, a wooded ridge which can be seen from several points along the river, and which is said to extend westward to Marten Mountain, at the east end of Lesser Slave Lake.

The channel of Pelican River above the portage is only a few feet deep, and affords no geological sections, seldom even cutting down to the boulder clay. The small amount of erosion

performed by this stream evidences an origin subsequent to the Glacial period.

Pelican Lake. Pelican Lake, the head of Pelican River, is a small lake about four miles in length and one to two miles in width, it is very shallow, and its water has the usual brownish colour of water issuing from muskegs. Its shores are low, and it is surrounded by shelving sandy and gravelly beaches.

Pelican Lake, like the majority of lakes in this district, occupies a shallow depression in the boulder clay and associated drift deposits, and has no connection in any way with the pre-glacial features of the country.

After crossing Pelican Lake, the traverse led up Beaver Creek, a small stream, in places, scarcely large enough to turn the canoe.

Beaver Creek. Beaver Creek was followed in a westerly direction for two miles, and as the stream then turned to the south, we left it, and made a portage of two miles across the watershed, between the Athabasca and Peace rivers, to Sandy Lake, one of the sources of Loon River.

Sandy Lake. Sandy Lake is rounded in outline, with a diameter of four to five miles, it is deeper than Pelican Lake, and its waters are clearer. Its height above the sea is 1,910 feet. Its shores are low, and like Pelican Lake, it occupies a hollow in the drift. Sandy Lake drains westward by Sandy Lake Creek into Wabiscaw Lake. Sandy Lake Creek is a stream of from fifty to seventy feet wide, and its length, measured in a straight line, is eleven miles.

About half way down, it expands into a small lake, and two miles further on falls over the Devil's Rapids, where it makes a descent of about fifty feet. A portage of about a mile in length leads past the rapids, but they are not dangerous. The country bordering Sandy Lake Creek is generally wooded, but opposite the rapids a large space has been cleared by fires, originating from the camping places at the ends of the portage, and now forms a typical prairie. At the Devil's Rapids, Sandy Lake Creek develops a small valley, but no rocks are exposed. In the greater part of its course its bed is only a few feet below the general surface of the country.

Wabiscaw lakes. At the head of the Wabiscaw River, are the two Wabiscaw lakes. The upper lake is about six miles long, and from two to three wide; its water is shallow and is filled with small algæ, probably belonging to the genus *Aphanizomenon*. South of the lake, the flat or slightly rolling plain, wooded with aspen and spruce, which characterize the region, is terminated at a distance of twelve to fifteen miles by a range of low hills, connecting Pelican and Marten mountains. In other directions no high land is visible.

The stream connecting the two Wabiscaw lakes is about three miles in length and winds sluggishly through a marshy flat covered with wild hay.

The lower Wabiscaw Lake is about eight miles long with an average width of three miles. It is deeper than the upper lake, and its water is clearer. Boulder clay is exposed in two places along its eastern shores, but no outcrops of the older rocks were seen. Numerous boulders occur along the beach in places. These consist principally of Archæan gneisses, but others of sandstone and limestone are not uncommon.

The Wabiscaw lakes are drained by the Wabiscaw River, which, with its continuation, Loon River, is the most important stream in the district examined ; it has a course of 290 miles and drains an area of about 14,200 square miles. The principal tributaries are Bear, Trout, House and Loon rivers, which join it from the west, and Wood Buffalo, Pine and Panny rivers, which enter it from the east. Most of these streams have their sources in lakes, but they have not yet been explored.

The Wabiscaw River, after leaving Wabiscaw Lake, runs in a south-easterly direction to Pine River, a distance of about forty-seven miles, in a straight line ; its width varies from 75 to 120 yards ;

for some miles from its head the current is sluggish and the channel of the stream is encumbered by numerous gneissic boulders, through which we had some difficulty in finding a passage. Twelve miles from the lake, Bear River joins the Wabiscaw from the west, and is almost equal to the latter in size. It heads in Bear Lake, but is continued under the name of Whitefish River to Whitefish Lake, and has only been partially explored. Above the junction of Bear River with the Wabiscaw, the latter is interrupted by a series of short rapids, but after passing these it is easily navigable for many miles. At the rapids the river cuts through a small ridge, and a valley about fifty feet deep is developed, while above and below the banks disappear, and the bed of the river is only a few feet below the general level. The adjacent country is all well wooded, chiefly with aspen, interspersed with groves of spruce. Five miles below Bear River, Trout River comes in from the same side. This stream is about sixty feet wide and originates from the Trout lakes. Below Trout River the Wabiscaw is easily navigable, the current averaging about two miles an hour, and is uniform in appearance until near Wood Buffalo River ; at this point the slope of the stream increases and rapids occur at the extremities of all the bends.

Character of adjacent country.

Current of rivers.

Channel changed.

Navigation.

Valley deepens.

Grand Rapids

Loon River.

From Wood Buffalo, to House River the current of the Wabiscaw is generally rapid, and stretches of rough water occur frequently. Two miles above House River a recent change in the course of the stream was noticed. Here the river, apparently within the last few years, has broken through the tongue of land separating two of the bends, and rushes with great velocity between the high boulder-clay banks of the narrow gap thus formed. The old channel is now quite dry for about two miles. Below House River the Wabiscaw winds for some miles through a flat, swampy region; further on it straightens out and runs with a swifter current through a somewhat higher region. Here a valley from fifty to sixty feet deep is gradually developed, but disappears again before reaching Pine River. From Pine River the Wabiscaw bends more to the west and runs in a general north-westerly direction towards the Buffalo Head Hills. Between Pine River and Two Lakes Creek, canoe navigation is comparatively easy, although a few small rapids occur about half way down. The average width of the stream is about 100 yards, and the current runs at a rate of from two to four miles an hour.

Two large tributaries come in from the north, the names of which I could not learn. Descending the Wabiscaw, its valley gradually deepens and at the mouth of Two Lakes Creek, it is 350 feet deep. The banks are generally wooded, chiefly with aspen, mingled in places with spruce. Twelve miles below Two Lakes Creek the Wabiscaw falls over the Grand Rapids, so-called, although they are not very formidable. These rapids are about a mile in length and consist of three distinct rapids; the upper two were run without trouble by keeping close to the left bank, but the lower one is shallower and crowded with boulders, and we were obliged to cross to the right hand and let the canoe down with a rope; at high water no trouble would be experienced in shooting the whole rapid. Nine miles below the Grand Rapids, Panny River, one of the largest tributaries of the Wabiscaw comes in from the east. This stream is about 100 feet wide, and is reported to head in Chippewyan Lake, but it has not been explored. A few miles lower down, Loon River joins it from the west and thence gives its name to the main stream. Loon River heads in Loon Lake, which is described on a succeeding page. Loon River is much smaller than the Wabiscaw, enters the latter at right angles, and has no geographical right whatever to give its name to the common stream. From the junction of the Wabiscaw and the Loon rivers, to Muddy River, a distance of about thirty miles in a straight line, Loon River has a current of about three miles an hour and is almost free from rapids. The valley is about 250 feet deep, and with its steep grassy and wooded banks often presents a very picturesque appearance.

Muddy River is about sixty feet wide ; it drains part of the Buffalo Head Hills, and its waters are usually discoloured by sediment, derived from the waste of the shales of which these hills are composed.

Below Muddy River, Loon River skirts the base of the Buffalo Head Hills for some miles, and appears to cut through their lower slopes, as the valley acquires an increased depth and assumes for some distance the appearance of a cañon. In this reach, steep banks often exceeding 400 feet in height, cut out of the dark Cretaceous shales, narrowly inclose the river. The current of the river is also swifter than usual, and strong, but easily-run rapids are numerous. The valley of the Loon River maintains its narrow gorge-like character for about fifteen miles, but before reaching Bat River the elevation of the country through which it cuts is suddenly lowered, the valley becomes shallower and wider, and the naked scarps are replaced to a large extent by woody and grassy slopes. Below Bat River the Loon River becomes very tortuous and continues so all the way to Peace River. The river flats become large and are occasionally partly open, in some cases giving evidence of having been cleared by ice. A few miles above its junction with Peace River the current of Loon River decreases to two miles an hour, the valley disappears, and the width of the stream increases to about 150 yards. Two miles above its mouth it receives Bear River, a small muddy stream coming from the direction of the Buffalo Head Hills.

The Loon-Wabiscaw River might possibly be navigated, by powerful steamers, as far as the Grand Rapids, during the season of high water, and by using the line occasionally, but with the exception of a few miles of still water above its mouth, it can hardly be considered a navigable stream.

Peace River.

Peace River is formed by the junction of the Finlay and Parsnip rivers, two transmontane streams, and is the largest and longest of the tributaries of the Mackenzie. It rises in, and drains a large district west of the Rocky Mountains, and then continuing eastwards, intersects the axis of that range, and drains the country lying along its eastern slopes, through four degrees of latitude. Its length, from the confluence of the Finlay and Parsnip rivers, to the point at which it unites with the waters flowing from Lake Athabasca to form Slave River is 757 miles, but measuring from Summit Lake, the source of its principal branch, it is approximately 905 miles.

Length of
Peace River.

Peace River forms the eastern boundary of the region embraced in this report, and was examined from the Smoky River Forks to the mouth of Red River, a distance of 311 miles.

Between Smoky River Forks and the mouth of Battle River, a distance of 108 miles, the general course of Peace River is northerly. Its average width in this distance is about 400 yards, but it occasionally expands to nearly twice this size. The current has a uniform rate of about four miles an hour. The valley is deep, and in places presents a very picturesque appearance. It is about two miles wide, and at the mouth of Smoky River the water is not less than 700 feet below the level of the plateau. Going northward the valley becomes gradually shallower, and at Battle River its bottom is only 600 feet below the plateau. The banks are often scarped, and where composed of sandstone are precipitous.

*Valley of
Peace River.*

*Traverse to
Wabiscaw
River.*

A short traverse was made on foot from a point about three miles above Battle River eastward to Wolverine River, and up that stream for some distance. After climbing out of the valley of Peace River, which is here 600 feet deep, we passed through a spruce, aspen, and Banksian pine forest, about a mile wide, and then entered a rolling country partially cleared by forest fires. Beyond this, all the way to Wolverine River, the trail crosses a succession of wide muskegs, sandy ridges, covered with Banksian pine, and loamy ridges, covered with aspen. Wolverine River, where we reached it, is a small sluggish stream about thirty feet wide. Its valley is about fifty feet wide, but the banks are not scarped, and no exposures were seen. We followed it up for about ten miles through small prairies, aspen woods and muskegs, and then, finding that it afforded no geological information, or prospect of any, we returned.

*Uniform ap-
pearance of
river.*

Below Battle River, to the Vermilion Falls and rapids, a distance of nearly 200 miles, Peace River is rather monotonous and the current is less rapid, having a uniform rate of about three miles an hour. The valley decreases in depth to about 100 feet, and the sandstone cliffs, which lend variety to the upper stretches of the river, disappear, and are replaced by grassy and wooded slopes, or by the sombre clay shales of the Cretaceous. Islands become more numerous, and the bars gradually change from gravel to sand.

*Traverse to
Buffalo Head
Hills.*

From Fort Vermilion, one of the establishments of the Hudson's Bay Company, 152 miles below Battle River, a traverse of about forty miles was made inland to the Buffalo Head Hills. For the first ten or twelve miles the trail led across a partially wooded and fertile prairie, and then through marshes, alternating with wooded ridges to Buffalo Lake, a small sheet of water from two to three miles long, and about



R. G. McConnell, Photo, July, 1889.

VERMILION FALLS, PEACE RIVER.

a mile wide. Buffalo Lake is bordered by extensive meadow lands, covered with luxuriant grass. After leaving it, we passed through an aspen wood, crossed two small streams flowing into Bear River, and then for some miles, travelled through a belt of partly wooded, partly open country, which lies at the foot of the Buffalo Head Hills. The greater part of the land just described, is well fitted for settlement.

The Buffalo Head Hills are about fifty miles long, and from twenty-five to thirty miles wide, with a height of 2,500 feet above the sea. Buffalo Head Hills. The northern and north-eastern escarpments are the boldest, and rise to a height of 1,000 feet above the plains at their base. To the southward, the relative elevation gradually decreases, and the hills appear to die away opposite Black River. The summit, so far as observed, is a level, slightly-rolling plain densely wooded with aspen and spruce.

Below Fort Vermilion, Peace River runs in an easterly direction for forty-six miles to the Vermilion Falls and Rapids. Vermilion Falls. Vermilion Falls, like the Cascade Rapids on the Athabasca, are caused by the river falling over a low limestone ledge. The height of the falls varies according to the volume of water. At low water they are from fifteen to twenty feet high, while at high water, they become greatly reduced, and on one occasion were descended in safety by a York boat. Peace River at this point is nearly a mile wide; the falls are not continuous all the way across, but are interrupted at several points by the higher portions of the limestone ledge. A mile above the falls a strong rapid occurs, a third of a mile in length, and these two obstructions constitute the only serious break in the navigation of Peace River for hundreds of miles.

Peace River was not examined below Vermilion Falls. In its Peace River below Vermilion Falls. lower stretches the river averages nearly a mile in width, the current is gentle and uniform and the valley almost disappears. A small rapid occurs at one point, but does not obstruct navigation except during low water.

Red River.

In the district reported on there are two Red rivers, one draining into Peace River and the other into the Athabasca. Both head in lakes situated within a few miles of each other on the Birch Mountains, and the Indians frequently carry their canoes from one stream to the other. The westward-flowing Red River empties into Peace River five miles below the Vermilion Falls. It is about 240 miles long, and averages about 200 to 250 feet in width. Its name is derived Two Red rivers heading in Birch Mountains.

from the reddish-brown colour of its waters. It was ascended for about 100 miles, measuring in three stretches along the river, but for fully 160 miles following the tortuous course of the stream.

Description of Red River. From its mouth, to Owl River (Oho sipi), a distance of fifty miles, measured in a straight line, Red River follows a general direction a little west of south. For some miles above its mouth it is confined by low limestone cliffs, and the current is swift, with occasional rapids. Further up, the limestone banks disappear, and the river winds for many miles between low boulder-clay, and mud banks, through a flat, wooded and monotonous country. Thirty miles above its mouth, rapids commence again, and extend for several miles, and a valley about 100 feet deep is developed. The plateau adjoining the river has been burnt over in places, and small prairie patches appear occasionally. Near the head of the rapids, the river has recently broken through the neck of one of the bends, and the water, pouring with great velocity through the new and much shortened channel, strikes the opposite bank with great force; a part of it is deflected up the old channel, and passing completely round the bend, a distance of about a mile, falls into the river again above the break. The curious feature is here presented of a river reversing its course for a considerable distance. This, of course, only happens when the river is flooded. Above the rapids the current gradually diminishes, the valley disappears, and the river continues to be easily navigable as far as Owl River; above Owl River, a small stream, fifteen to twenty feet wide, enters Red River from the left. At Owl River, Red River approaches to within a few miles of the Wabiscaw, and the Buffalo Head Hills, which are situated on the further side of the latter stream, are plainly visible at an estimated distance of ten to fifteen miles. Above Owl River, Red River bends almost at right angles to its former course and runs in a direction a little south of east to the Birch Mountains. A few miles above Owl River, rapids commence again, and short stretches of rough water occur frequently for fifteen or twenty miles, above which they disappear and the current remains uniform as far as Burnt River. Burnt River is a stream about forty feet wide and is the first large tributary of the Red River. Its water is dark and is evidently derived from the numerous muskegs of the region. Above Burnt River, small rapids reappear and increase in frequency until the river becomes

Burnt River. one continuous and wild rapid; and, as a walk of eight or ten miles up the valley showed the rapids to continue for that distance at least, it was decided to return, as our supplies were almost exhausted. In these rapids Red River has a fall of fully 250 feet over the western face of a gradual rise in the general elevation of the region. A view

Long rapids.

from the summit showed a range of hills in a direction which I took to be the Birch Mountains. From the foot of the long rapids, we descended to Peace River, easily in four days, although the ascent had cost us ten long days of hard labour.

Red River is not a navigable stream and can only be ascended, even in canoes, during high water. It is, however, quickly affected by rains, and the showery weather which we experienced while on it, kept it in a fairly high stage and enabled us to proceed. Like most of the streams in the district its valley is insignificant and affords little geological information.

Lesser Slave Lake.

Lesser Slave Lake is a long and comparatively narrow sheet of water, Description of extending in an east and west direction along the southern border of the region already described. It is sixty-one miles long, has an average width of eight miles, a maximum width of twelve miles, and covers altogether an area of 484 square miles. Lesser Slave Lake, notwithstanding its size, is very shallow, seldom exceeding ten feet in depth in low water, and over a large part of its area is much less. The deepest part of the lake lies to the east of the narrows, south-west of Marten Mountain. The north shore of the lake is fairly regular in outline, with stony and sandy beaches, while low bluffs of boulder clay and Cretaceous shales occur occasionally. The southern shore is nearly everywhere marshy, and affords no exposures. A series of plateaus from 800 to 1,000 feet high, of Laramie sandstone and shale, runs parallel with the southern shore at a distance of eight to ten miles, but decreases in height westward, and terminates in a low ridge running round the bay, which forms the western end of the lake. Along the northern side, the land slopes up from the shore to a height of 150 feet, but after passing Marten Mountain going eastward, it suddenly rises to a height of about 1,000 feet, forming the elevation known as Marten Mountain. This range of hills follows the north-eastern shore of the lake for some distance, and then stretches eastward to Pelican Mountain. No exposures were found on it, but it is evidently a continuation northward of the Laramie plateaus south of the lake.

Marshes covered with wild hay occur along the southern and western shores of Lesser Slave Lake, and a small prairie has been cleared by forest fires, north of the west end of the lake, but the country generally is covered with the same monotonous spruce and aspen forest which characterizes the whole northern region.

The principal streams flowing into Lesser Slave Lake, are, from the Feeder. west, Heart River; from the north, Salt Creek, the Narrows River

and Marten River ; and from the south, Swan River and two smaller streams, the names of which I did not ascertain. The outlet is from the eastern end, by Little Slave Lake River into the Athabasca. All of the streams emptying into Lesser Slave Lake are insignificant in size and can only be navigated in high water with small canoes. An attempt was made in September to ascend Marten River, which skirts the western base of Marten Mountain for some distance, but this was found to be impossible owing to the numerous piles of driftwood which blocked the river every few hundred yards. Heart River is reported to be navigable for a considerable distance, and by ascending it, and portaging for two miles, to a chain of lakes, canoes can be taken to Whitefish Lake.

Traverse from Lesser Slave Lake to the Wabiscaw River by Whitefish Lake, Bear Lake and Trout Lake.

Country between Lesser Slave Lake and Whitefish Lake.

The trail to Whitefish Lake leaves Lesser Slave Lake at the crossing of Salt Creek near its mouth, and runs in a general north-easterly direction. The distance in a straight line is twenty-eight miles. After leaving Lesser Slave Lake the trail leads across a hay-covered flat, only slightly raised above the lake, and then following up Salt Creek mounts the plateau which is here about 200 feet high and passes for some miles through a rolling well-grassed prairie, the evident product of forest fires. Ten miles from the lake, the limit of the open country is reached, and the trail enters the forest, and then winds along the dry wooded ridges which separate the numerous muskegs and beaver meadows with which the country abounds. Horse Creek, a small stream probably tributary to Heart River, is bordered by two miles of open country, after passing which the trail leads through an aspen forest nearly all the way to Whitefish Lake.

Whitefish Lake.

Whitefish Lake is from ten to twelve miles long, and four to six miles wide. Its shores are low and featureless, and it is surrounded on all sides by an aspen-covered country, which, if cleared would afford excellent farming land. It drains northwards by Whitefish River into Bear Lake, and thence into the Wabiscaw. It is 2,075 feet above the sea level. At its western end it is connected with a smaller lake by a sluggish stream two miles in length, on which is situated a small trading post belonging to the Hudson's Bay Company. A small clearing has been made in the vicinity of the post, and some potatoes and other garden produce are annually grown, but the inhabitants depend for their subsistence, principally on the whitefish with which the lake abounds, and from which it has taken its name.

From Whitefish Lake the trail to Trout Lake leads for some miles through an aspen forest, where the travelling is fairly good, and then crosses a succession of sphagnum-filled hollows, alternating with wooded ridges to Swampberry Creek (Wi-si-ki-ni-mi-ni Si-pi). This ^{Swampberry Creek.} stream is about twenty feet wide and flows through a wide valley with sloping wooded banks. It afforded no exposures. It was crossed shortly after reaching it and we followed down its left side through numerous muskegs and marshes until it emptied into a lake of the same name.

At Swampberry Lake the writer separated from the pack train, which ^{Canoe tra-}
^{verse to Bear}
^{Lake.} was sent on to Trout Lake, and made a canoe traverse to Bear Lake. Swampberry Lake is a shallow sheet of water about four miles long and one mile wide, and is surrounded by low marshy shores and spruce-covered flats. Its outlet, a small weedy stream from fifteen to thirty feet wide, empties, after a short course, into Whitefish River, the outlet of Whitefish Lake. This stream is about thirty feet wide. It has low banks overhung on both sides by willows, and flows at the rate of two to three miles an hour. No rapids were found on it, but it is occasionally blocked with piles of drift wood making portages necessary. It is extremely crooked, and at one point, a great bend, said to take nearly a day to go round, was avoided by making a short portage to a small lake. This was crossed, and its shallow and weedy outlet descended to Whitefish River, the whole traverse occupying about an hour. Below the portage, Whitefish River is from fifty to sixty feet wide, and winds for a number of miles through wide marshy meadows, in the middle of which it receives Shoal River, a small stream about twenty feet wide. Below Shoal River a ridge is crossed, the banks become higher, and the tamarack and willow are replaced by an aspen forest. A second wide marsh then appears, followed by a ridge, through which the banks are thirty feet high and show boulder clay in one or two places, but nothing older was seen. Beyond the ridge the bordering flats again become marshy and continue so until Bear Lake is reached.

Bear Lake receives two other small streams, besides Whitefish River ^{Bear Lake.} which we descended. It empties into Bear River which flows into the Wabiscaw twelve miles below Lake Wabiscaw. It is four to five miles long and about two miles wide, and, like the other lakes of the district, occupies a shallow basin in the drift. A low ridge skirts its eastern shores and a second ridge running south-eastward terminates in a rounded wooded hill near its outlet, and may afford exposures where cut by the river, but I was unable to visit it.

Trail from
Bear Lake to
Trout Lake.

From the mouth of Whitefish River we crossed to the northern end of the lake, then *caching* the canoe, set out on foot for Trout Lake. The trail led almost due north, through an aspen forest, with occasional swamps and muskegs. Nine miles from the lake we came to a small stream flowing eastward, and shortly afterwards to Trout River, which we followed up for two miles, and then crossed. Trout River empties the waters of Trout Lake into the Wabiscaw. It is a shallow but rapid stream about seventy feet wide, and has much clearer water than other rivers of the district. It skirts for some distance, and partly cuts through, the elevation known as Trout Mountain. Its valley showed no sections, and the loose rocks in its bed were exclusively Archæan, and afforded no indications of exposures in its upper part. After crossing Trout River, the trail led to the summit of a ridge about 300 feet high, forming part of Trout Mountain, and then continued parallel with Trout River, to Mudpout Lake (Ni-ye Sâ-gahâ-gan), passing through deep muskegs and over sandy ridges covered with Banksian pine the greater part of the distance.

Mudpout
Lake.

Mudpout Lake is an expansion of Trout River, and is about three miles long by a mile wide. It is connected with Trout Lake by a short stream, two miles long, on which is situated a small trading post of the Hudson's Bay Company.

Trout Lake.

From the Hudson Bay post at Trout Lake, an exploratory trip was made northward to the Wabiscaw River, in order to connect with the traverse down that stream. A guide and canoes were obtained at the fort, as the way led through a chain of lakes connected with Trout Lake. Trout Lake is divided into two parts, by narrows half a mile in length. The lower lake is five to six miles long, and four to five miles wide at its widest part. The comparatively clear condition of the water, is due to the latter passing through a chain of lakes, and on the way, depositing its sediment ; and is illustrated by the fact, that trout are obtained there in abundance. A wooded ridge follows the north-eastern shore of Trout Lake, and our guide stated that Manitou Lake lies behind this ridge. Strange tales are told of this lake by the Indians. Drums beaten by invisible hands have been heard by the awe-struck Indians ; fires have been seen at night dancing over the surface of the water, and Indians have mysteriously disappeared, their canoes being afterwards found right side up and uninjured.

Manitou
Lake.

The upper Trout Lake is ten miles long, and at its upper end widens into a bay six to seven miles wide. It is connected by a small winding stream with Good Fish Lake, a small body of water about two miles long. After leaving Good Fish Lake we crossed Rush Lake, and followed a short stream a mile and a half long into

Long Lake, and thence into Round Lake, the head of the series. The stream connecting Long Lake and Round Lake is two miles in length, and is interrupted by a series of rapids, necessitating a portage of half a mile.

From Round Lake a portage of nearly a mile is made to Kidney Lakes on Lake across the watershed separating Two Lakes Creek from Trout Trout Mountain. River. Kidney Lake is situated on nearly the highest point of Trout Mountain, and has an approximate elevation above the sea of 2,320 feet, or nearly the same as Birch Mountain. Two miles from Kidney Lake the trail reaches the edge of Trout Mountain, and a gradual descent of 320 feet is made. At the foot of this escarpment is Two Lakes, the source of Two Lakes Creek. Camped on the shore of this lake, I found a solitary Iroquois Indian the only representative of his tribe in the whole district. From Two Lakes a good trail led northward through alternating forest and muskeg to the Wabiscaw River, meeting the latter about a quarter of a mile below Two Lakes Creek. The valley of the Wabiscaw at this point is 350 feet deep, and the total descent from the top of Trout Mountain to the river is 820 feet. No sections of any kind were seen along the route examined.

After returning to Trout Lake, I accompanied the pack-train on the return journey to Lesser Slave Lake. For some miles from the Post at Trout Lake the country is of the most worthless description, wide muskegs alternating with sandy ridges covered with Banksian pine, and with occasional aspen-covered ridges. Five miles from Trout Lake we crossed a tributary of Trout River about thirty feet wide, winding between marshy flats in a valley about 100 feet deep, and seven miles further on came to Shoal River. From this point a side trip was made on foot to Loon Lake, the source of Loon River. An old trail, impassable for horses, owing to the numerous muskegs and marshes, but practicable on foot, was followed for a distance of about twenty-two miles, as far as Red Earth Creek, a tributary of Loon River. From Red Earth Creek we struck westward until we reached the Loon River, and then followed it up to the lake. Between the crossing of Shoal River and Loon Lake, muskeg and marsh alternate monotonously with pine and aspen ridges, and, with the exception of an aspen-covered strip along Loon River, very little country suitable for any purpose was seen.

Loon Lake proved to be much smaller than expected. It is about Loon Lake. seven miles long, with an average breadth of about two miles. It is shallow, with low banks, and is situated in the midst of a low wooded and marshy district. The eastern shore is bordered by a wide marsh, the home of innumerable flocks of wild fowl. Loon Lake is much lower than Trout Lake, being only about 1,660 feet above the sea.

After rejoining the pack-train, we continued south-westward along the Trout Lake trail, wading for most of the distance through muskegs and marshes to Swampberry Lake, where I separated from the pack-train on the way north. From Swampberry Lake back to Lesser Slave Lake the same trail was followed as on the way out.

General description of country north of Lesser Slave Lake.

The country north of Lesser Slave Lake, bordering the Trout Lake trail, may be described, generally, as a lightly rolling plain, elevated about 2,000 feet above the sea, the surface of which consists of a network of low ridges, wooded with aspen, spruce and Banksian pine, separated by muskegs, marshes, beaver meadows and shallow lakes, some of which are ten or twelve miles long. The streams are small and have little excavating power, seldom cutting through the drift to the rocks beneath, and consequently affording little geological information.

Athabasca River.

Athabasca River.

The Athabasca is the most southerly of the three great tributaries of the Mackenzie. It rises in the summit ranges of the Rocky Mountains between latitude 52° N. and longitude 54° N., and after a north-easterly and northerly course of 776 miles empties into Lake Athabasca. From thence, its waters are conveyed by Slave River to Great Slave Lake, and thence by the Mackenzie to the sea.

Portion examined.

The Athabasca was examined in the course of the present exploration, from its junction with Little Slave River to its mouth, a distance of 456 miles. Between Little Slave River and Athabasca Landing, a distance of 66 miles, the course of the Athabasca River is at first easterly and then southerly. Its width averages about 250 yards, and it occupies a valley 350 feet deep and about two miles wide. The current has a fairly uniform rate of three to four miles an hour, and the river is easily navigable.

At Athabasca Landing, which is the terminus of the cart trail from Edmonton, the goods required in the fur trade are shipped northward and westward by steamers and York boats, to the Peace, Athabasca, and Mackenzie River districts.

Rapids.

From Athabasca Landing to the Grand Rapids, a distance of 153 miles, the general course of the river is northerly, its width varies from 250 yards to 400 yards, and the current, except for occasional accelerations, is fairly steady at three to four miles an hour as far as the mouth of the Pelican River. Between Pelican River and the Grand Rapids, three rapids occur, viz., Pelican and Stony Rapids, and the Rapide du Joli Fou, so called on account of an unskilful steersman running his boat against the most conspicuous rock in the channel.

These rapids obstruct the navigation of the river in low water, but at medium or high water they are easily ascended and descended by the steamer plying between Athabasca Landing and the Grand Rapids. The river valley in this stretch is 300 to 400 feet deep, and the banks Valley. consist of a succession of slides due to the plastic character of the clay shales through which it is cut. The grade of the Athabasca River between the mouth of Little Slave River and the head of the Grand Rapids amounts to 2.72 feet per mile, the total fall being 596 feet.

At the Grand Rapids, the character of the Athabasca River entirely changes, its grade becomes greatly increased, and for the next Change at Grand Rapids. seventy-six miles, or as far as its junction with Clearwater River, there are swift and dangerous rapids every few miles. At the Grand Rapids the river falls between fifty and sixty feet in about half a mile. The rapids are caused by the river meeting and cutting through a soft sandstone terrane of the Cretaceous. This sandstone is filled with hard spherical concretions which become gradually liberated as the matrix is slowly worn away. The concretions, some of which are six to eight feet or more in diameter, now pave the channel of the river, and the water in its swift descent, breaks over them in a tumult of waves and foam. The Grand Rapids are unnavigable by craft of any kind. There is a small island about a quarter of a mile long opposite the worst part of the rapids; boats are brought down to the head of the island and their contents portaged across by means of a short tramway which has been built by the Hudson's Bay Company. From the foot of the island, the river is again navigable, but it continues rough for two or three miles. After passing the Grand Rapids, and the rough water below them, the Athabasca runs smoothly for over twenty miles, and then rushes down the Burnt Rapids. In this stretch the valley is deep and gorge-like. The banks are from 500 to 600 Deep valley. feet high and are often terraced by differential denudation. At the Burnt Rapids the river is shallow and filled with boulders, but the fall is not so great as at the Grand Rapids, and we had no difficulty in descending them. The canoe channel follows the left bank. The Burnt Rapids are followed by sixteen miles of smooth water, below Burnt Rapids. which the river falls in quick succession over the Boiler, Middle and Long Rapids, all of which occur within a stretch of seven miles. These three rapids are similar in character to the Burnt Rapids, and owe their existence to a steeper declination than usual, combined with an accumulation of boulders in the channel of the river. They are all navigable at ordinary stages of the water, both with canoes and York boats. Five miles below Long Rapids the river makes a sharp bend, at

Crooked
Rapid and
Cascades.

the extremity of which is Crooked Rapid, where two ledges of limestone project into the stream from the right side, but no trouble was experienced in running down close to the left bank. Below Crooked Rapid the river falls over several limestone ledges, forming Rock Rapids and the Little and Big Cascades. Small falls extending partly across the river occur at these points, but the ledges are broken down in places enabling boats to get through. Below the Cascades the river is unobstructed for eight or nine miles to Mountain Rapid. This rapid, like the Cascades, is formed by the river flowing over a low limestone ledge. A short portage was made here, but at certain stages of the water, a channel navigable by small boats exists near the centre of the river where the ledge has been worn down. Mountain Rapid is the last dangerous rapid on the river. Two miles above the Forks, Moberly Rapid was passed, but the fall there is slight.

Grade of river.

The fall of the Athabasca, between the head of the Grand Rapids and the Clearwater confluence, a distance of seventy-six miles, amounts to 360 feet, an average of 4·7 feet per mile.

Athabasca
River below
the Clear-
water.

Below the confluence of the Clearwater River the character of the Athabasca entirely changes, the rapids disappear, and the river, enlarged to a third of a mile in width, flows smoothly at an average rate of three miles an hour. The valley increases in width and the banks gradually decrease from an elevation of about 400 feet at the Forks to the level of the delta. In passing through the delta the channel divides in several branches, and new channels are constantly being opened and old ones closed by the spring floods. From the Forks to the head of the delta, a distance of 130 miles, and thence to Athabasca Lake, a further distance of thirty-one miles, the Athabasca offers no obstruction to navigation. The steamer "Grahame," owned by the Hudson's Bay Company, has been plying on this portion of the river for some years.

Traverse from the Athabasca to Moose Lake, Birch Mountains, and return by Moose River.

Trail to Moose
Lake.

The trail to Moose Lake leaves the Athabasca River about a mile below the mouth of Red River, and follows the valley of the latter for about five miles. At this point Red River bends away to the south, and the trail continues a little north of west across a wide muskeg to Moose River, which it crosses. At the crossing, Moose River is a rapid stream 100 feet wide, in a valley about eighty feet deep, the banks of which are formed of tar sands capped with dark shales.

From Moose River the direction of the trail is a few degrees north of west to the foot of Birch Mountain, a distance of about twelve miles. This district is slightly undulating, with a number of muskegs and marshes in the depressions, and is wooded chiefly with small aspen, spruce and Banksian pine.

The eastern escarpment of Birch Mountain, where the Moose Lake trail crosses it, is about 500 feet high, the ascent is easy, and is made in about two miles. From the brow of the escarpment the surface slopes gradually upward towards the centre of the plateau, where it is about 2,300 feet above the sea, or about 1,500 above the level of the Athabasca. The surface of the Birch Mountain uplands is rolling and drift covered, and near the Moose Lake trail, is indented by a number of old valleys holding small streams and lakes, which are evidently pre-glacial in origin.

The forest is similar in character to that covering the plains beneath, but has been largely destroyed by fires.

Moose Lake, the objective point of the traverse, is situated about twenty miles from the edge of the mountain, and occupies a wide depression about 300 feet below the level of the plateau. It is a shallow lake, about two miles long, and is separated into two parts by narrows, on the right side of which are two small huts, used at times by the Hudson's Bay Company as a trading post. It receives from the south, by a short stream, the waters of Buffalo Lake, which is seven to eight miles long and two to three miles wide, and northward is said to be connected by a series of small streams with a chain of five lakes.

The return journey from Moose Lake was made by water, in two small bark canoes, which we were fortunate enough to find on the lake.

Moose River, the outlet of Moose Lake, is sixty-five miles long, measured in two-mile stretches along its course, but following the bends it is fully 100 miles long. It has a total fall of 1,200 feet, or about twelve feet to the mile. Its grade is irregular, and its course is interrupted by several long and wild rapids.

After leaving Moose Lake, Moose River is wide and sluggish for two miles, and then its course is intercepted by a high ridge, in crossing which it contracts, and forms a rapid about a mile long.

Below the ridge it expands into a long shallow sheet of water known as Willow Lake, beyond which rapids continue until the river leaves the mountains. The fall in these rapids amounts to about 250 feet. From the foot of the mountains, the river winds gently along for fifteen or twenty miles, between low wooded banks. Between this reach and

the crossing of Moose River, three strong rapids, separated by short stretches of smooth water, were encountered. The rapids occur where the river cuts through the ridges which cross its course, and are always accompanied by a deepened valley. At the lower, or Big Rapids, the banks of the valley show the same nodular sandstone which outcrops at the Grand Rapids on the Athabasca, and the channel of the stream is encumbered by a multitude of nodules derived from this formation.

Canoes abandoned.

Both canoes were repeatedly broken in descending the numerous rapids. One was abandoned at the foot of the mountain, while the other was left at Big Rapid, which is situated only a few miles from the trail crossing, and we returned to the Athabasca on foot over the same trail used in beginning the traverse.

Between the trail crossing and the Athabasca, Moose River is said to be full of rapids and to be unnavigable.

Muskeg River.

Muskeg River.

Muskeg River enters the Athabasca from the east about thirty-one miles below the Forks. It was ascended for a distance of thirty miles. Like most of the other streams in the district, its lower part is unnavigable, and it is reached by making a portage from the Athabasca to a point on it, about three miles above its mouth. The portage track begins nearly opposite the mouth of Red River and is about a mile long. The general direction of the stream is north-easterly. For some miles above the head of the portage occasional exposures of limestone, capped in places with tar sands, occur in the banks, but further up, the valley disappears and the river winds through a low, marshy and worthless region. The stream here is about fifty feet wide and is blocked every few hundred yards with piles of drift wood and beaver dams. Before returning, a low wooded ridge running in a north and south direction between Muskeg River and the Athabasca was visited, but no exposures were found.

List of Elevations.

Elevations.

The following elevations were obtained by comparing the readings of two aneroids with the readings of the Standard mercurial barometers at Edmonton and Lake Athabasca. Heights obtained in this manner are necessarily only approximate:—

	Feet.
Athabasca River (at "Landing").....	1,650
" " (head of Grand Rapids).....	1,200
" " (at Clearwater Forks).....	840
" " (at mouth).....	690

	Feet.
Peace River (mouth of Smoky River).....	1,225
" (mouth of Battle River).....	1,090
" (Fort Vermilion).....	950
" (mouth of Red River).....	870
Athabasca Lake.....	690
Lesser Slave Lake.....	1,890
Whitefish Lake.....	2,075
Trout Lake.....	2,130
Loon Lake.....	1,680
Lake Claire.....	700
Long Lake.....	2,269
Kidney Lake.....	2,320
Pelican Lake.....	1,910
Buffalo Lake (Birch Mountains).....	2,000
Wabiscaw Lake (Upper).	1,720
" " (Lower).....	1,705
Wabiscaw River (mouth of Trout River).....	1,643
" " (mouth of Two Lakes Creek)...	1,484
" " (at junction with Peace River). .	920
Birch Mountains.....	2,300
Buffalo Head Hills.....	2,500
Marten Mountain.	2,890
Trout Mountain	2,350
Plateau south of east end of Lesser Slave Lake..	3,090

The general elevation of the region decreases going northwards from 2,200 feet, the height of the plains south of Lesser Slave Lake, to 700 feet, the height of the lower part of the Peace-Athabasca delta. The rate of decrease averages 6·9 feet per mile.

GEOLOGICAL SECTIONS.

Section on the Athabasca from the mouth of Little Slave River to Lake Athabasca.

From the mouth of Little Slave River to Pelican River the La Biche valley of the Athabasca is cut out of soft dark grayish or brownish shales (La Biche shales). These shales are usually rather coarsely laminated, are very plastic and when unsupported are easily affected by land-slips. They contain, besides the argillaceous material, nodules and small lenticular beds of limestone, numerous calcareous nodules, and occasionally thin beds of grayish and yellowish sandstone. Iron pyrites occurs in crystals and spherical crystalline aggregates scattered through the shales, and to its decomposition is doubtless in a large measure due the salts in the numerous mineral and chalybeate streamlets which trickle down the faces of many of the escarpments and often

Burnt shales.

Exposures of La Biche shales.

Horizontality of beds.

Fossils.

Age of lower part of La^a,^b
Biche shales.

Pelican sandstone.

form small red pools at their bases. At one point, about twenty-four miles below the mouth of Lake la Biche River, the La Biche shales have been baked and reddened for about 100 yards along their strike by the combustion of the carbonaceous matter which they contain, but the fires are now extinct.

Exposures of the La Biche shales are infrequent in the valley of the Athabasca above the mouth of Lake La Biche River, but below that point the sections are often continuous for miles. Approaching Pelican River the banks again become wooded and the shales are only occasionally seen. The attitude of the shales is horizontal so far as observed, but owing to the concealment of the bedding by slides, and the washing down of the soft material from above, with the lack of any definite horizon traceable from point to point, small dips, if present, would be unrecognizable.

Fossils although carefully searched for, proved to be extremely scarce. The following forms, all typical Pierre and Foxhill species, were found in an exposure about twenty-five miles above the "Athabasca Landing":

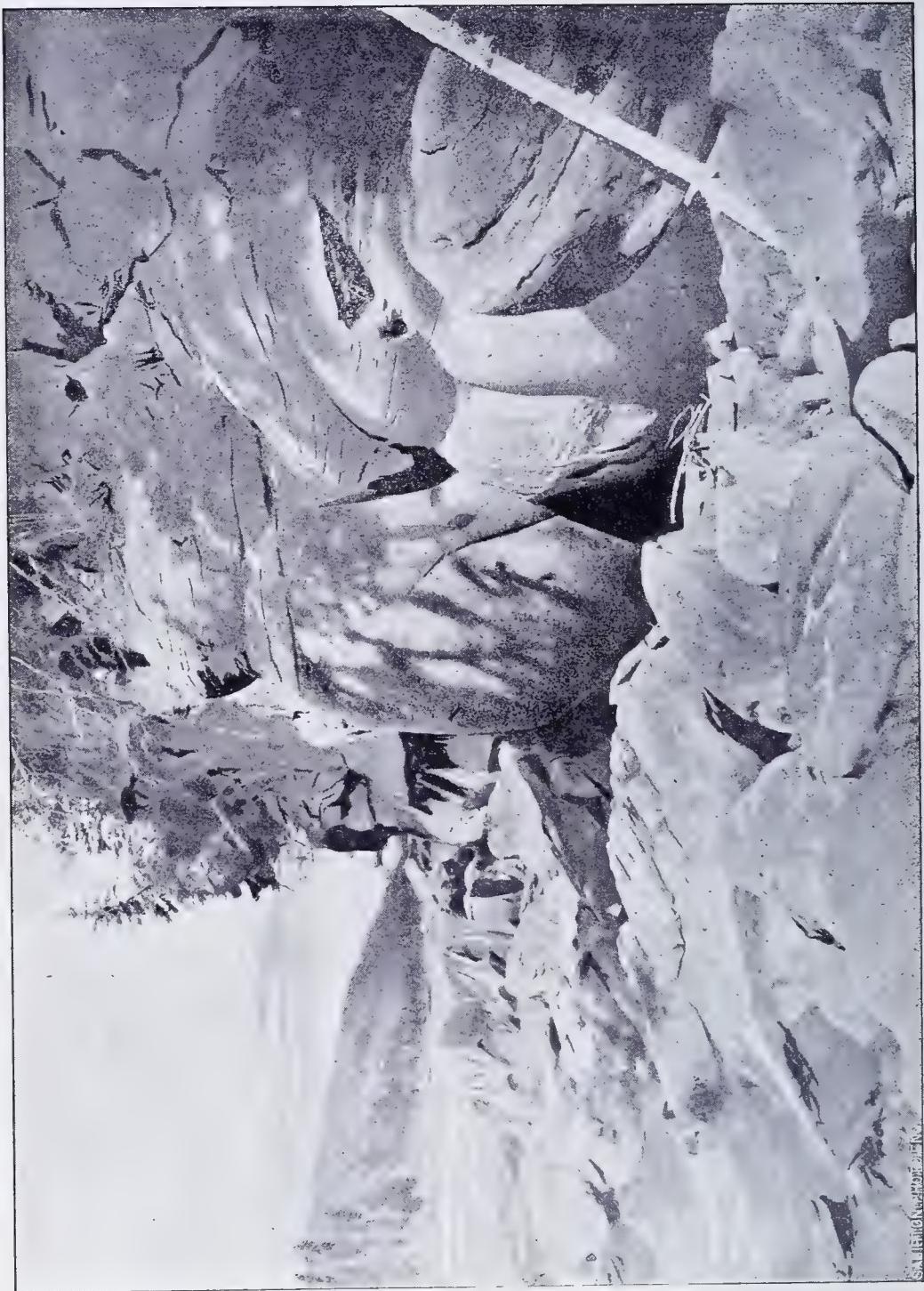
Tancredia Americana, Meek and Hayden.
Pteria Nebrascana, Evans and Shumard.
Modiola, sp.
Lunatia concinna, Hall and Meek.
Baculites compressus.

Below the mouth of Lake La Biche River, fragments of *Baculites compressus* and *ovatus* and specimens of *Ostrea congesta*(?) were found in a number of places, and at Stony Rapids, a few miles below the mouth of the Pelican River, I was fortunate enough to find some large well-preserved specimens of *Acanthoceras Woolgari*, Mantell, and a large *Desmoceras* since described by Mr. Whiteaves as *D. Athabascense*.*

The two latter fossils occur at the base of the shales, and with *Ostrea congesta*, which is usually regarded as a characteristic fossil of the Niobrara, seems to show that the lower part of the La Biche shales are older than Pierre.

At the mouth of Pelican River the shales are underlaid by a band of sandstone which for the sake of distinction may be called the Pelican sandstone. The Pelican sandstone has a slight dip to the south, of a few feet to the mile, and this added to the fall of the river, causes it to rise gradually in the banks of the valley. It is forty feet thick, and is usually conspicuously white, but is also tinged yellowish and brownish in places, by iron oxide. The lower beds as a rule are soft and crumbly, but towards the top, the granular constituents are cemented by iron, into a hard hemitiferous sandstone passing in

*Trans. Roy. Soc. of Can., vol. X., sec. iv.



R. G. McConnell, Photo, August, 1890.

NODULES IN GRAND RAPIDS' SANDSTONE.
GRAND RAPIDS, ATHABASCA RIVER.

places into a quartzite. No fossils were obtained from the Pelican sandstone and its exact position in the Cretaceous series is therefore doubtful.

Underlying the Pelican sandstone is a shale formation, which, from its intimate relations with the former, may be called the Pelican shale. It makes its appearance a short distance below the mouth of the Pelican River, and is a conspicuous feature in the valley of the Athabasca for many miles. The Pelican shale varies in thickness from ninety to 100 feet, and is very uniform in composition throughout. It is slightly darker and harder than the Pierre shales, and weathers down into a *talus* of small flaky particles. No fossils were obtained from it.

The Pelican shale is underlaid, about half-way between Pelican Grand Rapids River and House River, by a second sandstone formation, for which I propose the name of the Grand Rapids sandstone, as it is well developed at that point. The Grand Rapids sandstone is characteristically yellowish, but is also occasionally whitish, and is coarser-grained than the Pelican sandstone. It is remarkable for the large number of spherical siliceous concretions which it contains, and which range in size up to ten feet or more in diameter. It weathers into steep slopes and cliffs, the faces of which are often studded with the concretionary masses. Lignite seams, varying from a few inches to five feet in thickness occur at intervals through this formation. The following section was measured about ten miles above the mouth of House River. It is in descending order :—

Concretions.

Dark soft shales.....	100' +	La Biche shales.
Whitish and yellowish sandstone be- coming ferruginous above	20·00'	Pelican sand-
Shales and sands.....	10·00'	stone.
Sands and shaly partings.....	10·00'	
Dark shales.....	90·00'	Pelican shale.
Soft sandstone.....	4·00'	Upper portion of
Lignite	0·50'	Grand Rapids
Soft grayish and yellowish sandstone..	15·00'	sandstone.
<hr/>		
	249·50'	

Twenty feet of Grand Rapids sandstone exposed at this point has been grooved horizontally by river ice. At the mouth of House River 150 feet of the Grand Rapids sandstone is exposed, about half its total thickness, above which comes the Pelican shale and sandstone, and about 130 feet of the La Biche shales. At the head of the Grand Rapids, about 200 feet of the Grand Rapids sandstone is exposed. The lower portion near here consists of about fifty feet of a soft yellowish almost homogeneous sandstone, packed thickly with nodules, and weathering into almost vertical cliffs. Resting on this is about 100 feet of alternating sandstone and shales, then

Section at
House River.

fifty feet of greyish and yellowish sandstone overlaid by a seam of lignite four to five feet thick, above which comes the flaky Pelican shale. Below the Grand Rapids, the Grand Rapids sandstone is exposed for several miles in continuous and almost vertical cliffs, on both sides of the river. Nodules occur throughout the formation, but are more abundant in the lower part, and seams of inferior lignite were noticed at several points. Some of the beds by the addition of small quartz pebbles pass occasionally into a grit or fine-grained conglomerate.

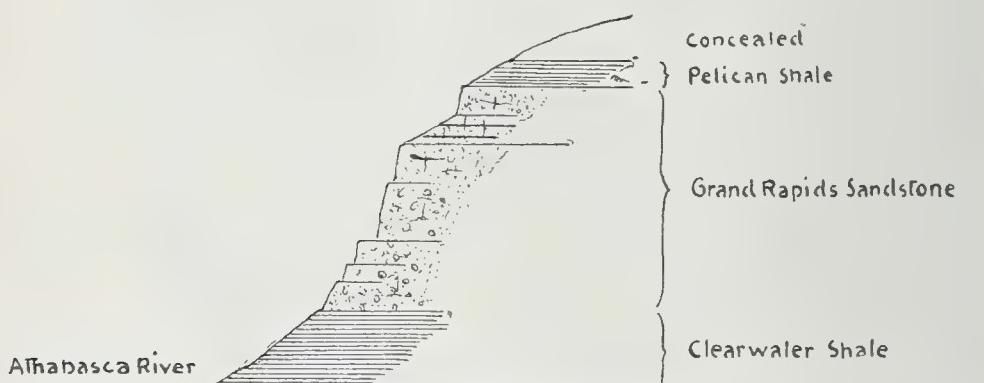
Clearwater shale.

Eight miles below the Grand Rapids at Pte. la Biche the Grand Rapids sandstone is underlaid by an argillaceous formation which will be referred to as the Clearwater shale, as it is well developed on that river. The full thickness of the Grand Rapids sandstone, (300 feet) is exposed at this point. It is overlaid by fifty feet of the Pelican shale. At the junction of the two formations, a small bed of ferruginous conglomerate was noticed. On the west side of the valley, in the Grand Rapids sandstone, there is a seam of lignite about four feet thick. The sandy beds immediately underlying the lignite, have been bleached nearly white.

Rocks at Pte. Brulée.

At Pte. Brulée, eight miles below Pte. la Biche, the valley is deep and gorge-like and a section is shown over 400 feet thick. The Clearwater shale has gradually risen and at this point has a thickness of 100 feet. It is less homogeneous than the Pelican shale, and holds, besides dark and lead gray shales and clays, a considerable proportion of grayish sandstone, greenish glauconitic sandstone and ironstone.

FIG 1



Section at Pte Brulée

Scale 300 Ff = 1 inch.

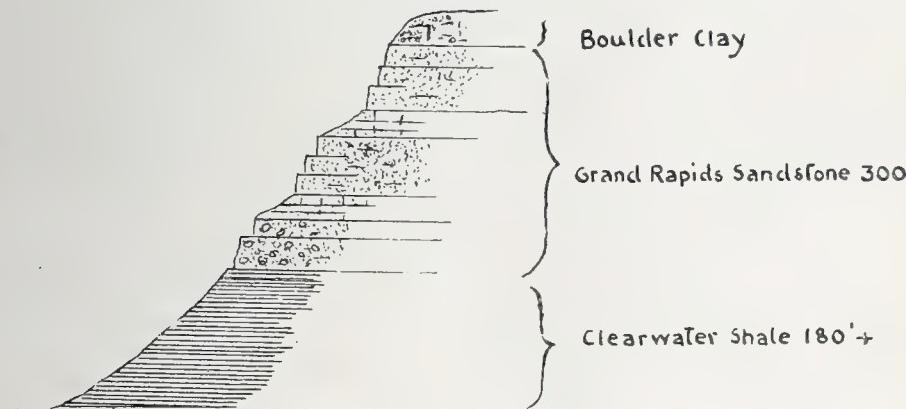
Above the Clearwater shale the Grand Rapids sandstone rises by cliffs and terraces to a further height of 300 feet. The lower part of the formation is yellowish and filled with nodular concretions, while further up grayish colours prevail and some of the beds become conglomeritic. Resting on the Grand Rapids sandstone is fifteen feet of flaky shales representing the lower part of the Pelican shale. This formation is apparently concealed by surface deposits near this point, as it was not seen to crop out further down the river.

At the Burnt Rapids the Clearwater shale, about forty feet above the surface of the river, holds a bed of greenish glauconitic sandstone about two feet thick, which is highly fossiliferous. The specimens are in a good state of preservation, but most of the species are new and on this account their value in the determination of the horizon in which they were found is greatly lessened. The fauna has, however, a general Benton aspect. Mr. Whiteaves furnished me with the following list of fossils collected at this point as the result of a preliminary examination: Fossils at a *Camptonectes*, a *Modiola* allied to *M. tenuisculpta*, Whiteaves; a *Yoldia*, like *Y. Evansi*, Meek and Hayden; a *Nucula*, a *Protocardium*, *Callista tenuis*, Hall and Meek; a *Mactra*, a *Cinulia*, *Desmoceras affine*,* Whiteaves; and *Hoplites McConnelli*,* Whiteaves.

Rocks at
Burnt Rapids.Fossils at
Burnt Rapids.

Below Burnt Rapids the Clearwater shale overlaid by the terraced Grand Rapids sandstone, is exposed in magnificent sections on both sides of the deep trough-like valley. The following illustration shows the general arrangement of the beds.

FIG 2



Section three miles below Burnt Rapids, Athabasca River.

Scale 300 ft = one inch.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

Fossils in
Clearwater
shale.

Ten miles below Burnt Rapids some fossils were collected from a sandstone bed in the Clearwater shale, among which are *Callista tenuis*, Hall and Meek, a *Mactra*, a *Yoldia*, a *Nucula*, and a *Cinulia*.

Tar sands.

At the head of Boiler Rapid, forty miles below the Grand Rapids, and 193 miles below Athabasca Landing, the base of the Clearwater shale rises above the surface of the valley and uncovers the *Tar sands*, the lowest local division of the Cretaceous. The Tar sands must have

Origin of Tar
sands.

consisted originally of almost unconsolidated sands and soft sandstone, ranging in texture from a fine silt to a coarse grit, but have been cemented into a coherent tarry mass, 200 feet thick, by the heavy constituents of the oils which have welled up during past ages, in almost inconceivable quantities from the underlying Devonian limestones. At Boiler Rapid, fifteen feet of the Tar sands are exposed, overlaid by 275 feet of the Clearwater shale, which is its ordinary thickness, above which comes the nodular sandstone and the yellowish and grayish sandstone of the Grand Rapids division. The Clearwater shale at this point yielded *Desmoceras affine*, Whiteaves, a *Goniomya*, and a *Thracia* or *Tellina*.

Rocks at
Middle
Rapid.

At Middle Rapid, three miles below Boiler Rapid, forty feet of the Tar sands are exposed. The sands are heavily saturated with tar at this point. They are overlaid by the Clearwater shale and the Grand

Thickness of
Tar sands.

Rapids sandstone. Two miles below Long Rapid 100 feet of the Tar sands are exposed, and at the head of Crooked Rapid this is increased

to 140 feet, the full thickness of the formation at this point. The Tar Sands at Crooked Rapid are massive and show false bedding below, but are stratified in more regular beds above. The saturation is less than usual, and to this fact is due the brownish colour of the beds. Two miles above Crooked Rapid the base of the Tar sands rises above the surface of the water, and discloses a few feet of grayish crumbly evenly-stratified Devonian limestones. The contact between the two formations is apparently conformable and affords little evidence of the vast interval of time which separates them.

Anticlinal at
Crooked
Rapid.

Crooked Rapid marks the summit of a low anticlinal. Above this point the beds dip in a south-westerly direction at from five to ten feet to the mile, while below, the general dip is to the north, but is very slight, as it averages less than two feet to the mile, and is just about equal to the fall of the river.

Exposure of
limestone.

Between Crooked Rapid and the Forks, the lowest beds exposed consist of a few feet of grayish evenly-stratified Devonian limestone. Ledges of this rock cross the river at several points and form small falls and cascades. The limestone is affected by a number of small folds and in two or three places sinks below the surface of the valley.

It is terminated upwards, for some distance below the Crooked Rapid, by a thin bed of conglomerate, consisting principally of sub-angular limestone pebbles ranging from half an inch to an inch in diameter. Siliceous grains fill up the interstices between the pebbles, and the whole is hardened into a compact rock by a calcareous, and in places ferruginous cement. A second variety of this rock consists largely of small ironstone concretions.

Resting on the limestone and well exposed in high cliffs on both sides of the river, is the black plastic mass of the Tar sands. At the Cascade Rapid, this formation is 150 feet thick and is so saturated that pure tar oozes out of the bank in several places and Tar streams. streams down the slope.

The Tar sands increase in thickness, descending the river, from 140 feet at Crooked Rapid to 200 feet at the Forks. The peculiar cleavage, Cleavage. mentioned by Bell*, which they affect in many places, has no general direction, but is usually nearly parallel to the face of the adjoining cliff. Flat plates, an inch or more in thickness, peel off easily and regularly from the ends of many of the beds, but the tendency to cleave does not appear to penetrate far from the surface.

The Grand Rapids sandstone was not observed below the Crooked Rapid. Between that point and the Forks, the upper part of the valley section consists of about 250 feet of the dark and lead gray shales, clays and sands of the Clearwater shale. The beds of this formation are not bituminous.

Below the Forks, or the confluence of the Athabasca and Clearwater, the valley of the former loses its narrow, gorge-like character and becomes wider and shallower, but still continues to afford good sections of the rocks. Evenly-bedded limestones of Devonian age, Devonian limestones. rising from fifteen to twenty feet above the surface of the river, are almost continuously exposed for a long distance on the right bank. They are horizontal, or nearly so, for some miles below the Forks, but further down, undulate in gentle folds, but seldom show more than the upper fifty feet of the terrane. The limestone is grayish, but often weathers to a light yellow, and is usually more or less argillaceous, in places passing into a calcareous shale. Fossils are numerous, among others, a large Stromatoporoid of variable shape is especially noticeable, from its abundance and size, in most of the sections. The following list of fossils collected between the Forks and Red River is furnished by Mr. Whiteaves :—

Chonetes Logani, var. *Aurora*, Hall.

Strophalosia productoides, Murchison.

* Geological Survey, Report of Progress. 1882-83-84, p. 15 C. C.

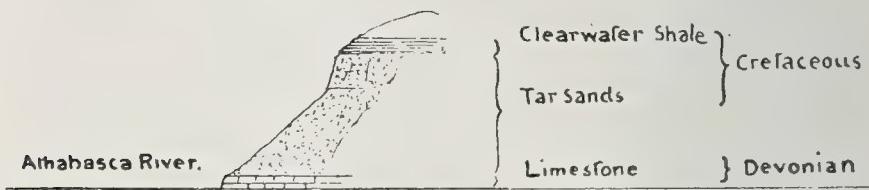
- Productella dissimilis*, Hall.
Spirifera subattenuata, Hall.
 " *inutilis*, Hall.
 " *tullia*, Hall, var.
 " *Richardsoni*, Meek.
Atrypa Angelica, var. *occidentalis*, Whiteaves.
 " *reticularis*, L.
 " *reticularis*, var. *aspera*, Schlotheim.
Actinopteria Boydii, Conrad.
Ptychopteria aequivalvis, Whiteaves.
Leptodesma Demus, Hall.
 " *Jason*, Hall.
Conularia Salinensis, Whiteaves.
Aparchites mitis, Jones.

These fossils indicate a horizon in the Upper Devonian probably nearly equivalent to the Cuboides zone.

The Devonian limestones are overlaid for some miles below the Forks by heavy sections of the Tar sands, but on account of the decrease in the height of the valley, the Clearwater shale almost disappears.

Disappear-
ance of Clear-
water shale.

FIG. 3



Section Six Miles Below Forks

Scale 300 Ft = 1 inch

Description of
Tar sands.

The Tar sands hold in places lenticular beds of limestone, lignite seams two or three feet thick and fragments of fossil wood. They vary in colour according to the quantity of tar they contain, from a gray to a dark brown, and jet black. Where heavily saturated streams of tar issue from the banks during the heat of summer, and form pools at the bases of the escarpments. This appears to be the origin as suggested by Bell* of the "tar springs" which occur in the right bank opposite Tar Island, two miles below the mouth of Red River, and in numerous other places.

* Geological Survey, Report of Progress, 1882-83-84, p. 22 C. C.



SARIBSTON PHOTOENG.

R. G. McConnell, Photo., July, 1890.

LA SALINE, ATHABASCA RIVER,
SHOWING DEPOSIT FROM MINERAL SPRING.

At La Saline, twenty-eight miles below the Forks, several mineral springs occur about half a mile east of the river on the edge of the valley there sixty feet deep. The deposits from the springs, consisting principally of calcareous tufa, cover the face of the escarpment and have also built up a cone on the top of the bank ten to fifteen feet high and about 200 feet wide. An analysis of the water which is strongly saline, is given in another place. Sulphuretted hydrogen gas escapes from the bank in several places and taints the air for some distance from the springs. Besides the calcareous tufa the cone contains small deposits of common salt, gypsum and native sulphur, while pure tar derived from the Tar sands beneath issues from the bank in two places. The springs feed a shallow lake which is situated at the foot of the escarpment, and is surrounded by a clay flat partly bare and partly covered with coarse grasses.

Devonian limestone is exposed for a couple of miles below the mouth of Red River, but below that point sections seldom occur. There are two small exposures about a mile below Red River, and the limestones are again brought up by a low anticlinal two miles and a half below Calumet River. At this point they are overlaid by fifty feet of light coloured shale. A number of fossils were collected here, from among which Mr. Whiteaves has identified the following species :—

- Cyathophyllum Athabascense*, Whiteaves.
- Spirorbis omphalodes*, Goldfuss.
- Hederella Canadensis*, Nicholson.
- Ascodictyon stellatum*, Nicholson.
- Crania Hamiltoniae*, Hall.
- Productella dissimilis*, Hall.
- Orthis striatula*, Schlotheim.
- Strophodonta demissa*, Conrad.
- Spirifera subattenuata*, Hall.
- “ *inutilis*, Hall.
- Cyrtina Hamiltonensis*, Hall.
- Athyris parvula*, Whiteaves.
- Atrypa reticularis*, L.
- “ “ var. *aspera*, Schlotheim.
- Rhynchonella pugnus*, Martin.
- Aparchites mitis*, Jones.

The last exposure observed of Devonian limestone occurs about ten miles below the Calumet River, or sixty-three miles below the Forks. The beds here have a slight southerly dip. They are fossiliferous, but the species collected, with the exception of *Campophyllum ellipticum* and *Cyrtina Billingsi* are the same as those enumerated in the list

given above. A short distance below the limestone outcrop, some sandstone beds dipping in the opposite direction occur, the exact relations of which are obscure. These beds hold vegetable remains and while soft and tar-soaked in some places, in others they pass into a quartzite. They are unfossiliferous.

Tar sands disappear.

A quarter of a mile below the last limestone exposure the Tar sands, sections of which, ranging in thickness from a few feet to 200 feet, are almost continuously exposed below the Forks, also disappear, and from this point on to the mouth of the river only the boulder clays and associated beds were seen.

These Tar sands are well saturated, and are twenty-five feet thick on the east side of the river, and fifteen feet on the west side, where they hold a small bed of lignite. They are overlaid by forty feet of soft reddish sands, belonging to the period of the Saskatchewan gravels, above which comes a few feet of boulder clay.

Twelve miles below the last exposure of the Tar sands, and about two miles above the mouth of Red Earth Creek, a copious saline spring bubbles up about 100 feet from the west bank of the river and feeds a considerable stream. Large quantities of sulphuretted hydrogen gas escape at the same place and taint the air for half a mile around. An analysis of the water is given in another place.

Superficial beds.

The superficial beds through which the valley of the Athabasca cuts in its lower part are described under the heading of Glacial Geology. They consist of an upper and lower sandy deposit, separated by red and dark boulder clays. The upper sands and gravels are soaked in places near the surface with tar, and contain beds of sandy nodules cemented by the same material.

Sections on Moose River, Muskeg River, Lesser Slave River and other tributaries of the Athabasca.

Moose River. Moose River affords the best geological section of any of the tributaries examined. A description of this stream is given in a previous chapter. It forms the outlet of Moose Lake situated near the centre of the Birch Hills, and after a course of about 100 miles, during which it describes a great bend to the south, it falls into the Athabasca forty-six miles below the Forks.

Gray shales. Two miles below Moose Lake at the first rapids encountered, an exposure of grayish shales holding ironstone nodules was observed. No fossils were collected, but from their stratigraphical position there is little doubt that the shales belong to the La Biche series. Five miles lower down a section of boulder clay seventy-five feet thick was observed, and two miles further on an exposure showed several beds of

boulder clays, separated by layers of sand and gravel, the whole overlying the grayish La Biche shales. The following section in descending order was measured at this point :

	Feet.
Sand and gravel.....	8
Boulder clay.....	4
Stratified sands.....	2
Boulder clay.....	3
Stratified gravels holding large boulders.....	3
Boulder clay.....	3
Gray shales with large limestone concretions.....	40
	<hr/>
	63
	<hr/>

Four miles below the last exposure, Moose River leaves the Birch Mountains, and winds for some miles through the plains at their base. Boulder clays are exposed along this stretch in a number of places, and dark evenly-bedded shales come to the surface at two points. Ten miles from the foot of the Birch Mountain escarpment, Moose River cuts through a ridge 120 feet high, and for some miles the valley affords good sections. The rocks here exposed consist of forty feet of whitish sands underlaid by twenty feet of dark plastic clays or shale. These beds represent the Pelican sandstone, and shale of the Athabasca section. They are underlaid by a few feet of sandy shales and sandstone, belonging to the Grand Rapids sandstone. A lignite seam two feet thick was observed in two places near the top of the Grand Rapids sandstone.

The Cretaceous rocks are overlaid by a boulder clay band fifty feet thick.

In the next few miles the sandstones of the Grand Rapids division are frequently exposed, and often hold numerous nodules similar to those characterizing the same formation on the Athabasca.

After cutting through the ridge mentioned above, Moose River bends at right angles to its former course and follows a general north-easterly direction to the Athabasca. Two miles below the bend the river cuts through the Grand Rapids sandstone and exposes the upper part of the Clearwater shale. Below this point the banks are low for some miles and exposures are infrequent, but further down, the valley increases in depth and almost continuous sections of the Clearwater shale are exposed. The rocks of this division consist here of plastic clays and shales, alternating with sandy shales and occasional beds of sandstone and ironstone. Some fossils were collected, among which are the same species of *Nucula*, *Yoldia* and *Camptonectes* found in

Exposures at
foot of Birch
Mountain.

Rocks on
Moose River

the Clearwater shale on the Athabasca. The beds have an easterly dip, and at the Big Rapids they are overlaid by the nodular sandstone of the Grand Rapids division. The following section was measured at the latter point:—

	Feet.
Boulder clays	10
Sandy shales	15
Nodular sandstone	20
Sandy shales	15
Clays and shales	40
	<hr/>
	110

Moose River was not followed for some miles below the Big Rapids, and at the crossing of the Moose Lake trail, the next point examined, the Clearwater shale comes to the surface and is underlaid by sixty feet of Tar sands.

Comparison of Moose River and Athabasca River sections. The Moose River section in its general character resembles that on the Athabasca, but differs in some of the details. The Pelican shale has decreased from ninety to twenty feet in thickness, and the Pembina shale appears to have become differentiated into an upper part consisting of sandy shales and sandstones, and a lower and more purely argillaceous division.

Red River.

Red River, which empties into the Athabasca twelve miles above the mouth of Moose River, shows, for some miles above its mouth, thick sections of the Tar sands, overlying the Devonian limestones.

Muskeg River

Exposures on Muskeg River

Muskeg River was examined for thirty miles from its mouth. This stream joins the Athabasca from the east about two miles above Red River. It is reached from the Athabasca by a portage, as the lower two or three miles are unnavigable. Tar sands overlying Devonian limestones are exposed for the first three or four miles above the head of the portage, when the limestones disappear, but Tar sands occasionally outcrop for ten or twelve miles further. In the upper part of the valley no exposures were seen.

A mile above the head of the portage the Tar sands, here only twenty feet thick, are overlaid by a bed of hard sandstone or quartzite, which has become developed in them, probably by siliceous infiltration. A mile above the last exposure a crevice in the Devonian limestone was noticed, which had become filled up with well-saturated Tar sands, derived from the overlying formation.

The section on Muskeg River shows that the Tar sands extend at least eight miles east of the Athabasca River.* They are much

*Since writing the above Mr. D. B. Dowling has found a small exposure of Tar sands on Firebag River, eighteen miles east of the Athabasca River.

thinner than usual, but this is probably due to the upper part having been removed by denudation.

Steep Bank River, which enters the Athabasca twenty-one miles below the Forks, was ascended for about ten miles on foot. Tar sands, overlaid by the lower part of the Clearwater shale, were exposed all the distance. Steep Bank River.

A trip was made from the Forks up the Clearwater River to the mouth of Pembina River, and thence up the latter stream for some miles, until the water became too shallow to continue the traverse.

The Clearwater, below Pembina River, winds along a great valley two miles wide and from 300 to 400 feet deep, which looks much older than the valley of the main river above the junction. Three miles above the Forks an exposure of Tar sands was observed, and three miles further up, Devonian limestones appear at the surface and recur at intervals all the way up. The limestones are similar in character to those on the Athabasca and hold the same fossils. Clearwater River.

The Pembina was ascended for thirteen miles in a straight line. Its valley is deep and gorge-like and affords many good sections. For some miles above its mouth Devonian limestones holding *Atrypa reticularis*, *Spirifera inutilis* and other fossils, undulate along the edge of the water and are then replaced by the Tar sands, many sections of which, in varying states of saturation, occur at all the bends of the river. Five miles above the mouth of the Pembina a seam of lignite, four feet thick, occurs in an exposure of the Tar sands, and a short distance further on a lenticular bed of quartzite, six feet thick and 100 yards long, was observed, somewhat similar to that found on Muskeg River. Five miles further up the Tar sands are overlaid by the Clearwater shale holding some fossiliferous beds, in which were found species of *Cyprina*, *Nucula*, and a *Yoldia* like *Y. scitula*. Two miles above the last section the Tar sands, overlaid by the Clearwater shales, are again well exposed. In the valley opposite this exposure several saline springs. bubble up close to the left bank of the river. The valley was not examined above this point.

The Pelican River was ascended to its source, but it afforded no exposures above the head of the portage made to overcome the rapids at its mouth. Below the portage, sections of the La Biche shales are present, but do not differ from those on the Athabasca.

Lesser Slave River affords a couple of small sections of La Biche shales, in one of which a specimen of *Baculites compressus* was found, Lesser Slave River. but in its upper part it does not cut through the drift deposits.

Lesser Slave Lake.

Lesser Slave
Lake.

Lesser Slave Lake rests on the La Biche shales but owes its existence to an embankment of drift deposits at its eastern end. Its shores are low and often marshy, and exposures of the older rocks seldom occur. Grayish calcareous shales, holding ironstone, were noticed east of the Narrows River, and sections of dark shales, holding *Baculites compressus*, occur near the eastern end of the lake, opposite Marten Mountain. A high plateau skirts the southern shores of the lake at a distance of eight or ten miles, and a small nameless stream was examined, which flows from it into the south-east corner of the lake. Sections showing beds of hard yellowish sandstone, alternating with sandy clays and sands, occur on the lower part of this stream. Some of the beds are fossiliferous, and the following species, with, others were collected :—

Protocardia borealis, Whiteaves.

Pteria Nebrascana, Meek and Hayden.

Anchura Americana, Meek and Hayden.

Fossiliferous
beds.

Foxhill sand-
stones.

Lignite seams.

Marten
Mountain.

These beds rest on the La Biche shales, and evidently represent the Foxhill sandstone. They were found as high as 160 feet above the lake, and are overlaid by the sands, sandy clays and sandstones of the Laramie, numerous sections of which occur all along the valley and in the scarped face of the plateau. Lignite seams were observed at several horizons, the thickest of which measured three feet, and a conspicuous bed of soft yellowish homogeneous sandstone fifty feet thick occurs at the foot of the plateau. The Laramie beds have a thickness of about 1,200 feet, but appear to be unfossiliferous throughout.

Marten Mountain north of the lake, was examined, but no sections were found on it, although fragments of lignite and sandstone are abundant on its lower slopes. It is 1,000 feet high and must be composed largely of Laramie as the rocks in this region are practically horizontal. A loose fragment of sandstone found at its base afforded specimens of *Limnaea* and other fresh water shells.

Section on the Wabiscaw and Loon Rivers.

Wabiscaw
River.

The Wabiscaw River for many miles below Lake Wabiscaw does not cut through the boulder clay. The first exposure of the older rocks noticed, occurs about nineteen miles below Pine River, nearly in line with the continuation of the Birch Mountains, and consists of light grayish soft shales, holding ironstone and calcareous nodules, similar to those overlying the Pelican sandstone on the Athabasca, and capping the Birch Mountain. Small sections of shale underlying the boulder clay again

occur at the Grand Rapids, eight miles above the mouth of Panny River, after having been concealed for a long interval. The next exposure occurs twenty-six miles further down, or about ten miles below the junctions of the Loon and Athabasca rivers, and consists of fifteen feet of soft falsely-bedded sandstone, passing into a fine conglomerate. The coloration varies from white to red. Two miles further down, the same sandstone outcrops again with an exposed thickness of thirty feet, but is here overlaid with 100 feet of dark shales holding ironstone nodules, which probably represent the Fort St. John shales. The arenaceous band below, so far as the stratigraphical evidence goes, appears to be a continuation of the Peace River sandstones. Approaching the Buffalo Head Hills, the valley of the Loon River deepens and scarped banks are more numerous. A mile above the mouth of Muddy River, a cut bank showed seventy feet of soft, grayish sandy shales, interstratified with a few beds of grayish and greenish sandstone and ironstone. A number of fossils were collected from this section, among which are *Desmoceras affine*, var. *glabrum*, a species first described by Mr. Whiteaves from Peace River, *Hoplites Canadensis*, Whiteaves*, found also in the lower part of the Peace River sandstones on Peace River; casts of a *Trigonia*, a *Mactra*, an *Axinæa*, and a *Lunatia*.

Below the mouth of Muddy River, Loon River breaks through the Narrow gorge. lower slopes of the Buffalo Head Hills, and has cut out for some miles a deep narrow gorge with banks 400 feet high in places, chiefly composed of a succession of land-slips. Dark and grayish shales, usually in a soft and plastic condition, are exposed all along this stretch. The shales are sandy in places and include thin beds of gray and greenish limestone and layers of calcareous and ferruginous nodules. Fossils were found at several points, and the collection, besides those enumerated above, includes a *Yoldia* like *Y. Evansi*, which is indistinguishable from the one obtained from the lower part of the Peace River sandstones on Peace River and from the Clearwater shale on the Athabasca, a *Teredo* boring into fossil wood, a *Lima*, and a *Pecten*.

After passing the Buffalo Head Hills, the valley of the Loon is greatly reduced in depth, and its banks for some miles are composed of boulder clay overlying stratified sands and gravels. In the vicinity of Bat River the shales reappear and are exposed in several places underlying the boulder clay. A mile below Bat River, specimens were found of the large *Desmoceras*, since described by Mr. Whiteaves under the name of *D. affine*. This fossil occurs in the Clearwater shale at Boiler Rapid on the Athabasca, all along Peace River, from the first

Exposures on
Wabiscaw
River.

Valley
deepens.

Fossils.

Shales reap-
pear.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

appearance of the Cretaceous above Vermilion Falls, up to Cadotte's River, and it was also found on Red River. It characterizes the lower part of the Cretaceous section in the vicinity of Peace River, and on the Athabasca the beds immediately overlying the Tar sands.

Three miles below Bat River the Loon enters and traverses for some miles a basin filled with glacial deposits. In this stretch the valley is about 100 feet deep and its banks show sections of boulder clay, often seventy-five feet or more in thickness. This clay is dark and very plastic, and holds numerous concretions, evidently derived like the main part of its substance from the underlying shales. It is usually underlaid and occasionally overlaid by stratified sands and gravels, and in one section was divided into two distinct divisions by a layer of well-rounded boulders.

Seventeen miles in a straight line, below Bat River, the boulder clay rises and the shales appear again above the surface. At this point they are grayish, and very soft, but hold a few hard beds of calcareous sandstone or impure limestone, and numerous variously shaped calcareous ironstone and clay nodules. Fossils were found at two points, among those collected being a *Yoldia*, and several specimens of the same large *Desmoceras* referred to above.

Exposures of shales.

The shales are exposed along the river for a distance of eight miles, measuring in a straight line. At the end of this stretch, the valley almost disappears, but small sections of boulder clay continue to be exposed almost to the mouth of the river. The boulder clay here is stained red in places, and holds beds of nearly pure red clay similar to those on Peace River, in the vicinity of Fort Vermilion.

Comparisons with Peace River section.

The Wabiscaw-Loon Cretaceous section resembles in its general features that on the Peace River, but differs from it in the less importance of the central arenaceous division. On the Loon River, thirty feet of sandstone was observed at one point, but as a rule the sandy beds alternate with much greater thicknesses of shale, and this stream appears to mark in one direction the vanishing point of the great sand bank which stretched with gradually diminishing thickness from the Rocky Mountains into the Cretaceous sea.

Section on Red River.

Valley of Red River.

The valley of Red River is very shallow, seldom exceeding 100 feet in depth, and the geological section it affords is very imperfect, as it is interrupted by long intervals, in which the river fails to cut through the drift. Limestones of Devonian age occur at its mouth, and extend up the valley for two miles in low cliffs bordering both sides of the stream. The limestone is nodular and crumbly and weathers to a light

cream colour. It is filled with corals, brachiopods and other fossils belonging to the same species as those previously enumerated as occurring at the Vermilion Falls. Above the limestone exposures, the valley shows only dark and reddish boulder clay for twenty miles. Two large gypsum boulders, probably brought hither from Peace Point on Peace River, were noticed about half-way up this stretch. Above the boulder-clay basin, dark shales representing the lower part of the Cretaceous series appear, and are exposed at intervals for eight or ten miles. The shales include limestone and calcareous nodules, and are similar in appearance and composition to those on the lower part of Loon River, and they also hold numerous specimens, in various stages of growth of the same *Desmoceras* (*D. affine*, Whiteaves).

Exposures in
Red River
valley.

Six miles above the shale occurrences, a small anticlinal brings cream-coloured Devonian limestones to the surface, holding *Atrypa reticularis* and other fossils. The limestones are only shown in one place, and the valley, for many miles above, is destitute of any exposures older than the drift. The shales appear again for a short distance near the mouth of Owl River. At this point Red River approaches within fifteen miles of the Buffalo Head Hills. Above Owl River, the Red River valley, so far as ascended, yielded no exposures of the older rocks.

Devonian
limestone.

Plateaus of the District.

The rocks of the Peace-Athabasca region are everywhere practically horizontal, as the dips seldom exceed a few feet to the mile, and such highlands as exist necessarily owe their origin to differential denudation. The principal highlands are the Buffalo Head Hills, Birch Mountains and Marten Mountain.

Rocks, hori-
zontal.

The Buffalo Head Hills may be described as a plateau of circum-denudation still lingering in the angle between the Loon and Peace rivers, and its geology is very simple. A description of the plateau is given on another page. It is 2,500 feet above the sea, and has a maximum height above the plains at its base of 1,000 feet. The escarpments are generally wooded, but good sections were found at the northern end of the plateau on a small tributary of Bear River, a feeder of the Loon. These sections show the plateau to be entirely composed of shales. The shales are of a dark colour but weather to a light gray and at a distance look almost white. They are soft and plastic and are very uniform in composition throughout. Nodules occur, but are comparatively scarce, and no fossils of any kind were obtained. As in other places, many small streams highly charged with salts of various kinds, furrow the lower slopes of the escarpment.

Buffalo Head
Hills.

Plateau com-
posed of
shales.

Thickness of
Cretaceous
sections.

The exposures in the Buffalo Head Hills, together with those on Loon River, show that the Cretaceous section in this part of the district has an approximate thickness of 1,500 feet, all of which, with the exception of a few sandy beds about 500 feet above the base representing the horizon of the Peace River sandstones, consists essentially of shales, and is probably of Benton age. The beds above the sandstone horizon correspond to the Fort St. John shales, while those below are referred to the Loon River shales of the Peace River section.

Birch Moun-
tain.

Birch Mountain is a name given to a great ridge situated west of the Athabasca, in the south-eastern part of the district reported on, and extending in a northerly and southerly direction nearly parallel with the course of that stream. It is nearly 100 miles long with an average width of about thirty-five miles. Its elevation above the sea is approximately 2,300 feet, and it overlooks the surrounding plains from heights ranging up to about 1,000 feet. The surface is undulating, the depressions being frequently filled with lakes, and except where cleared by forest fires, the whole ridge is densely wooded. The slopes are usually easy, and exposures, except at the southern end, are confined to the valleys of the streams.

Composition
of plateau.

Genetically, Birch Mountain, like the Buffalo Head Hills, is a plateau of circumdenudation, carved out of the horizontal beds of the Cretaceous, but it has been somewhat modified by glacial action. Sections were examined on Moose River, and on Steep Bank Creek, a small stream flowing into Lake Claire. At the former place, the plateau, so far as ascertained, is formed entirely of the grayish and dark shales, which on the Athabasca overlie the Pelican sandstone. No fossils were obtained from these shales on Moose River, but on the Athabasca, they contain a Pierre and Foxhill fauna above, while the lower part of the band is probably Benton.

Rocks on
Steep Bank
Creek.

On Steep Bank Creek, the shales still cover the summit of the plateau, but they are underlaid by a band of yellowish and grayish sands and soft sandstone, exposures of which also crop out at various points round the northern end of the mountain. These beds are destitute of fossils, but on stratigraphical evidence, there is little doubt that they represent the continuation of the Pelican and Grand Rapids sandstones, although the Pelican shale, which separates these two on the Athabasca, is absent here. The sands contain small coaly seams, and some of the beds are blackened with bituminous matter. They have an exposed thickness of 200 feet, but the base is concealed. The Clearwater shale and the Tar sands which underlie the Grand Rapids sandstone on the Athabasca, if present here, are also hidden, as the next rocks seen in descending the river consisted of crumbling Devonian limestones, but these occur some miles from the foot of the plateau.

Swift Current Creek, a tributary of Birch River, was examined up to the foot of the Birch Mountain plateau, but no exposures were found on it, although pebbles of tar-soaked sandy shales were found on a number of the bases, and point to an occurrence of the Tar sands in the north-western part of the ridge. Swift Current Creek.

The plateau south of Lesser Slave Lake was examined only in one place, and a description of the sections obtained is given on page 40. Plateau south of Lesser Slave Lake.

It consists of Laramie sandstones and shales holding lignite seams, overlying 150 feet of Pierre and Foxhill beds. Marten Mountain north of Lesser Slave Lake, is probably built of similar beds, but the section, except at the base where Pierre shales are shown, is concealed.

Sections on Peace River.

Peace River was examined from the mouth of Red River up to the Peace River Smoky River Forks. The portion of the river below Red River was traversed by Professor Macoun in 1875. Rock exposures in this stretch seldom occur, but grayish limestones interbedded with white gypsum, and holding *Strophodonta demissa* and other Devonian fossils are described as outercapping at Rapid Bouillé or Little Rapid, and extending down the river to Peace Point, a distance of fifteen miles. Rocks at Peace Point. Below this point, no rock exposures were noticed by Macoun until Quatre Fourches River was reached, where Archæan gneisses outercrop*.

Above Red River, Devonian limestones are exposed in low cliffs along the shore to the Vermilion Falls, and for two miles beyond. The limestone is horizontal and occurs in thick evenly-stratified light grayish or cream-coloured beds alternating with softer and more argillaceous bands. The latter are often stained reddish or greenish, and are easily eroded, and the origin of the falls is due to their gradual waste, and the consequent undermining and breaking down of the heavier beds. The limestones in the vicinity of the falls, have an exposed thickness of sixty feet. They do not appear to be bituminous. Some of the beds are very fossiliferous, the following species, among others, being collected here :—

Exposures at Vermilion Falls.

Cyathophyllum cæspitosum, Goldfuss.

Phillipsastræa Hennahi, Lonsdale.

Pachyphyllum Devonicense, Edwards and Haime.

Pachypora cervicornis, De Blainville.

Alveolites vallorum, Meek.

“ *Rœmeri*, Billings.

Monotrypella Unjiga, Whiteaves.

Strophodonta demissa, Conrad.

“ *perplana*, Conrad.

* Rep. of Prog., Geol. Surv. of Can., 1875-76, pp. 89-90.

Spirifera disjuncta, Sowerby.

Atrypa reticularis, L.

" " var. *aspera*, Schlotheim.

Rhynchonella cuboides, Sowerby.

Cryptonella Calvini, Hall.

Pterinea flabellum, Conrad.

This fauna agrees very closely in its general characters with that occurring in the Devonian limestones on the Athabasca, and indicates that the basement rocks on the two rivers, occupy a similar position in the geological scale.

Above Vermilion Falls and Rapids, the Devonian limestones disappear, and for some miles only the boulder clays and associated beds are exposed in the banks. Further up the dark shales of the Cretaceous

Appearance of
Cretaceous.

make their appearance, and are shown in frequent exposures all the way to Fort Vermilion. The general horizontality of the Devonian limestones in the region between the Peace and the Athabasca is shown by their disappearing below the surface in ascending these streams, at almost the same height, viz., 930 feet above the sea. The contact between the Devonian and Cretaceous rocks is concealed on Peace River, but there is little doubt that the limestones are directly overlaid by shales, and that the sands soaked with tar, which occupy this position on the Athabasca are absent. The shales seen between Vermilion Falls and Fort Vermilion are of a dark colour, and are only slightly indurated. They contain occasionally, thin beds of limestone, and more frequently layers of ironstone, and calcareous concretions. The latter are often fossiliferous, specimens of *Desmoceras affine*, Whiteaves, being especially abundant although usually in a more or less fragmentary condition.

Contact with
Devonian
concealed.

Rocks be-
tween Fort
Vermilion and
Battle River.

Between Fort Vermilion and Battle River, a distance measured in a straight line of eighty-five miles, but following the course of the river of about 150 miles, there is little change in the geology of the Peace River valley. Dark shales holding large limestone concretions, short lenticular limestone beds, nodular beds of ironstone, and occasionally a bed of sandstone, are exposed at all the bends of the river, and occasionally are shown for miles in continuous sections. The shales are uniform in composition throughout. They are very soft, almost passing into clays in places, and like the shales on the Athabasca and Saskatchewan, break away in frequent slides. Reddish ferruginous streamlets issue from the shales at almost every section, and often feed small pools lying in the hollows caused by the slides. The shales do not appear to be bituminous to any extent, but inspissated bitumen was observed at several points lining cracks in the nodules. Fossil wood is very abundant in some of the sections.

The shales are overlaid nearly everywhere by heavy sections of Boulder clay. boulder clay, usually associated below, here as elsewhere, with stratified sands and gravels. The boulder clay for some distance above and below Fort Vermilion, shows the same red coloration as that noted in the vicinity of Red Earth Creek on the Athabasca.

Three miles below Battle River, the shales are interbedded with a band of bluish, yellow-weathering, soft sandstone and sand, about seventy feet thick, which makes its first appearance in the left bank about 150 feet above the level of the river. The shales above and below the sandstone band are similar in appearance, and are apparently simply a continuation of those exposed lower down the river, but the formation is here divided by the sandy intercalation. The thickness of the shales underlying the sandstone is uncertain, but is probably in the neighbourhood of 500 feet.

Above Battle River the sandstones which may be provisionally named the Peace River sandstones, rapidly increase in thickness and appear to have a slight southerly dip, as the lower shales gradually disappear. At the great bend which Peace River describes, about fifteen miles above the mouth of Battle River, the cut banks show 100 feet of dark shales holding limestone nodules, above which comes fifty feet of bluish and yellow sandstone, followed by 100 feet of alternating sandstones and shales. The valley here is nearly 700 feet deep, but the upper part of the section is concealed. The lower band of sandstone weathers into cliffs and holds some beds resembling the green sand bed of the Clearwater shale on the Athabasca, but they are apparently not glauconitic. A number of fossils were collected from the sandstones, but they are nearly all undescribed species.

Rocks at bend
above Battle
River.

Five miles above the bend just referred to, the Peace River sandstones descend to the surface of the valley and the lower shale division disappears. The Peace River sandstones at this point are 230 feet thick, showing an increase in volume since first observed below Battle River of 210 feet. Part of this increase appears to be due, however, to arenaceous beds replacing the shales in the lower shale division. A section of the sandstone division shows eighty feet of yellowish sands and shales, holding numerous nodules of various kinds, and short beds of yellowish limestone, above which comes forty feet of sands and sandstones, interbedded with small lignite seams, and holding numerous fragments of fossil wood. The upper part consists of about 110 feet of alternating sands and shale, resting on which are 200 feet or more of dark shales, representing the Lower or Fort St. John shales of Dr. G. M. Dawson's Peace River section. A number of fossils were collected from the Fossils. lower part of the sandstones, among which are *Callista tenuis*, and a *Yoldia* like *Yoldia Evansi*, both of which were found in the Clear-

Increase in
thickness of
Peace River
sandstones.

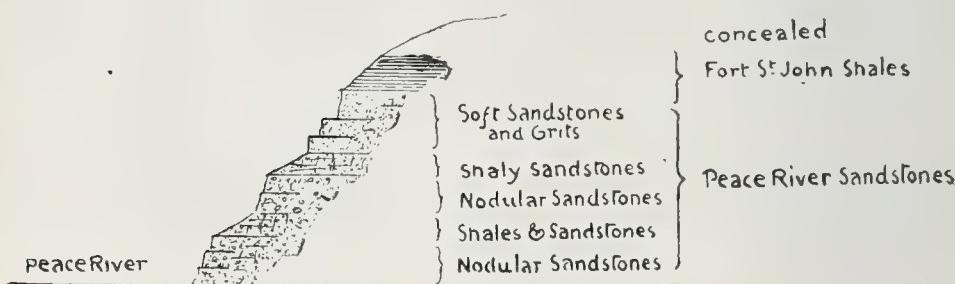
water shales on the Athabasca. Besides these, the collection includes two species of *Nucula*, a *Panopaea*, n.sp., a *Campstonectes*, a *Mactra*, a *Protocardium*, an *Axinea*, a *Lunatia*, an *Inoceramus*, specimens of *Desmoceras affine*, and *D. affine*, var. *glabrum*, Whiteaves, *Hoplites Canadensis*, Whiteaves, and a tooth of *Ptychodus*. The Fort St. John shales hold numerous ironstone nodules, but no fossils were obtained from them. Twenty miles below Cadotte's River, the banks of the valley showed the following section, in descending order : —

	Feet.
Dark shales (Fort St. John).....	200
Brownish shales, with yellowish clay	10
Yellowish sands.....	6
Alternating sands and shale, with some ironstone.	70
Yellowish sands.....	20
Yellowish sandstone.....	8
Yellowish sands.....	20
Yellowish striped sands and clays, with ironstone and limestone concretions (fossiliferous).	60
	<hr/>
	294
	<hr/>

Section at
mouth of
Cadotte's
River.

Opposite the mouth of Cadotte's River, the Peace River sandstones consist of 100 feet of sandy shales, holding ironstone and siliceous nodules, followed by forty feet of yellowish sands studded with large sandy concretions similar to those in the Grand Rapids sandstone on the Athabasca, above which, and underlying the Fort St. John shales, comes ninety feet of yellowish sands and shales, interbedded with numerous layers of ironstone. Between Cadotte's River and Tar Island, the Peace River sandstones are well exposed in cliffs, terraces and sloping banks all along the valley.

FIG. 4



Section near Tar Island

Scale 300 Ft = 1 inch

Above Cadotte's River the Peace River sandstones become more completely arenaceous, and the lower part is filled with fantastically shaped sandy nodules, some of which are fifteen feet or more in diameter. The general appearance of this formation as developed along this part of the river, is strikingly similar to that of the Grand Rapids sandstone on the Athabasca. It consists of three sandstone divisions, which weather into steep cliffs, separated by shaly bands, forming sloping terraces. The two lower sandstone divisions are of a yellow colour and carry nodules, while the upper one often shows grayish tints, and is occasionally conglomeritic. Fossils are scarce along this part of the river, but fragments of Ammonites and other marine fossils occur in many of the nodules. Numerous nodules. Scarcity of fossils.

A saline spring, emitting natural gas and carrying up small quantities of tar, occurs on the boulder beach at the upper end of Tar Island, about thirty miles below the Smoky River Forks, and a short distance further down, cracked nodules, with the fractures filled with inspissated bitumen, were noticed in the right bank. A second spring is reported to occur on an island opposite the mouth of White Mud River, but this was not seen. Saline spring.

Opposite Tar Island and for some distance above, the Peace River High cliff. sandstones are shown in high cliffs on both sides of the river, but they become influenced near this point by a slight southward dip, and ascending the river they gradually decrease in height, and at length disappear just below Smoky River Forks. When last seen they consist of a few feet of soft grayish massive sandstone, marked in a peculiar manner by thin curving lines of carbonaceous shale. Two miles below the Forks the sandstones here showing an exposed thickness of twenty feet, have been grooved and fluted horizontally by river ice. At the base of this cliff, are several small springs emitting sulphuretted hydrogen gas. At the Forks the whole valley section, 700 feet in height, consists of the dark ironstone bearing shales of the Fort St. John series, crowned by a varying thickness of boulder clay and associated beds. These shales, which have overlaid the Peace River sandstones since the first appearance of the latter below Battle River, were frequently searched for fossils without result, and its fauna is still represented only by the *Inoceramus* and *Buchiceras*, or *Acanthoceras, cornutum* found by Dr. Selwyn, near Fort St. John, in 1875. Gas springs. sandstones dip below the surface. Fort St. John shales.

Peace River was not examined by the writer above the Smoky River Forks, as the upper part of the river was explored by Dr. Selwyn, in 1875. The shales of the Fort St. John series are described by him, as extending up Peace River, above the Forks, for a distance of about twenty- Peace River above the Forks.

five miles, where they are overlaid by the sandstones and shales of the Dunvegan group. The latter then occupy the valley all the way to the cañon of the Mountain of Rocks, except for some distance above and below Fort St. John, where they rise above the surface and the Fort St. John shales appear. Above the cañon of the Mountain of Rocks, Peace River enters a region of tilted beds, and the sequence of the formations becomes obscure. The Dunvegan beds have a minimum thickness at Dunvegan of 600 feet, but appear to thicken rapidly westward, and probably include the whole 2,000 feet or more of sandstones and shales, shown in the escarpments of Table Mountain. The fossils collected by Dr. Selwyn from this formation, include fresh water, brackish water and marine species, and the general character of the fauna is similar to that of the Belly River series of the Great Plains, and the Bear River beds of Wyoming.

Thickness of
Dunvegan
beds.

Smoky River
section.

The Smoky River section above the Forks, was examined by Dr. G. M. Dawson, in 1879. Here, as on Peace River, the valley is occupied for about twenty-five miles by the Fort St. John shales. These are succeeded by 100 feet of sandstones, representing the Dunvegan group, above which comes 350 feet of shales, holding numerous fossils, most of which belong to the typical Pierre and Foxhill fauna, but Benton forms were also found. The shales are overlaid by sandstones and shales, belonging, so far as known, to the Laramie, but it is probable that here, as in the plateaus south of Lesser Slave Lake, some of the lower beds may be of Foxhill age.

GENERAL GEOLOGY.

ARCHÆAN.

Archæan
area.

A small area of Archæan gneisses occurs in the north-eastern quarter of the region reported on, but they were only hastily examined. They occupy the northern shore and neighbouring islands of Lake Athabasca, and are also found in the islands of Lake Mammawee, and in the rounded knobs projecting above the delta deposits bordering Quatre Fourches River. The gneisses here have a typical Laurentian appearance. They are usually reddish, but in places are strongly and evenly banded with alternating red and dark tints. The texture varies from medium to fine-grained, and the foliation is usually distinct, the rock passing in one or two places into a mica or chlorite schist. Both hornblendic and micaceous varieties are present, but these minerals in many instances are largely replaced by chlorite. Epidote occurs in large quantities. The gneisses dip at high angles, and the strike varies from ten to twenty degrees west of north.

CAMBRIAN.

An examination of the southern shore of Lake Athabasca was made from the mouth of Athabasca River to near Point William. This shore, as a rule, is low, and is bordered for long distances by low bluffs, composed of recent sands' and clays. At Pointe de Roche and at another point seven miles further on, the underlying rocks are exposed and consist of a granular siliceous sandstone, which, from its general character and position, probably belongs to one of the divisions of the Cambrian. For reference it may be called the "Athabasca sandstone." No fossils were found in it, nor was its contact with the overlying or underlying rocks observed. This sandstone is usually coarsely granular in texture, but passes occasionally into a fine-grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed by the textural differences. It is cut by two systems of jointage planes, and in weathering, breaks into huge blocks, some of which contain several hundred cubic feet of material.

Numerous fragments, some of large size, of a mottled red and green fine-grained sandstone, somewhat similar in appearance to that found at Sault Ste. Marie, were noticed strewn along the track, but were not found *in situ*.

The Athabasca sandstone apparently extends all along the southern shore of Lake Athabasca, as specimens brought by Mr. Cochrane, in 1882, from the east end of the lake, cannot be distinguished in appearance from those collected at Pointe de Roche and neighbouring localities. Its extension southwards, has not as yet been approximately determined. On the north its junction with the Archæan is concealed beneath the waters of Lake Athabasca.

DEVONIAN.

Devonian limestones crop out from beneath the Cretaceous, along the northern part of the district. On the Athabasca they rise to the surface at Crooked Rapid, and occupy the bottom of the valley down to a point about ten miles below Calumet River, except in a few places where they are carried below the surface by synclinal folds.

Below this point they are covered by recent deposits, and their junction with the underlying rocks is concealed. From the Athabasca, the Devonian limestone extends in a broad band round the southern end of Birch Mountains, and across Lake Claire to Peace River, and up the latter stream to a point two miles above Vermilion Falls.

Dip of limestone.

The Devonian limestones on the Peace and Athabasca rivers have a general northerly dip of three or four feet to the mile, and are also affected in some places by a series of small subordinate folds, few of which, however, succeed in bringing into view more than the upper 100 feet of the formation.

Characters of Devonian limestone.

The limestone is very uniform in character throughout the district. It is grayish or light yellowish in colour, and is evenly stratified, the beds ranging in thickness from two inches to several feet. It is usually more or less argillaceous, and in places passes into a calcareous shale. The purer beds are often nodular and crumbly, but resist denudation more successfully than the shaly varieties, and now frequently form long horizontal lines of relief, running across the faces of the exposures. Some of the beds are bituminous, but seldom to an important degree, and the sources of the oils which have saturated the overlying Cretaceous sands must occur beneath the exposed part of the formation. That the oils have risen from below, is shown by the cracks and fissures lined with bituminous matter which occur in the limestone in various parts of the district, and through which the liquid has evidently escaped.

Absence of formations between Devonian and Cretaceous.

The Devonian limestone is apparently succeeded conformably by the Cretaceous, and with the possible exception of a thin bed of conglomerate of limited extent, which occurs below Crooked Rapid on the Athabasca, the age of which is doubtful, the vast interval of time which separated the two formations, is, so far as observed, unrepresented, either by deposition or erosion. This can hardly be explained, except on the assumption that the formation during all this period, was buried far from land in the depths of some abyssal ocean, as the only other alternative, viz., that its surface represents a former base level of erosion, is, in view of the remarkable persistency of the upper beds, scarcely credible.

Fossils.

Lists of the Devonian fossils collected are given in the description of the Athabasca and Peace River sections.

CRETACEOUS.

Range of Cretaceous.

The Cretaceous section in the Peace-Athabasca country includes beds ranging in age from the Laramie to the Dakota, but the lithological succession of the various divisions, differs from that which obtains on the Great Plains, and also varies in different parts of the district. This feature of the formation, together with the further fact that most of the fossils collected are new to science, and therefore useless for the purpose of correlating the beds here with known horizons elsewhere, makes it difficult to classify the different terranes in a satisfactory manner, and also renders necessary the provisional use of some

Difficulty in classification.

new names. The following illustration shows the succession of the various divisions of the Cretaceous on the two rivers, and also their ages, so far as the stratigraphical and palæontological evidence at hand admits :

Athabasca River Section.

Laramie.	Laramie.	Wapiti River sandstones.
Foxhill sandstone.		Foxhill sandstone.
La Biche shales (upper part.)	Montana.	Smoky River shales.
Unrepresented.		Dunvegan sandstone.
La Biche shales (lower part.)		
Pelican sandstone.		Fort St. John shales.
Pelican shale.	Colorado.	Peace River sandstones.
Grand Rapids sandstone.		Loon River shales.
Clearwater shale.		
Tar sands.	Dakota.	Unrepresented.

Peace River Section.

Exposures of
Laramie.

Laramie.—The Laramie occurs in the southern part of the district, and is well exposed in the plateaus south of Lesser Slave Lake. The north-eastern boundary of this formation crosses the Saskatchewan in Long. $112^{\circ} 30'$ and runs in a north-westerly direction, crossing the Athabasca near the mouth of the Pembina, to the east end of Lesser Slave Lake. From this point it bends to the west, and extends in a sinuous line along the foot of the plateaus south of the lake, and thence in a westerly direction to Smoky River, beyond which its course, as yet, is only a matter of conjecture. An outlier of Laramie forms the upper part of Marten Mountain north of the east end of Lesser Slave Lake, and probably caps the highlands extending eastward from this elevation towards Pelican Mountain.

In the plateaus south of Lesser Slave Lake, the Laramie has a minimum thickness of 1,000 feet. It is practically horizontal and consists of yellowish and grayish flaggy and massive sandstones, often holding large nodules, alternating with grayish and dark clays and shales. Thin ironstone beds occur frequently throughout the section, and several seams of lignite were seen, the largest of which is three feet thick, but is of inferior quality. Fragments of fossil plants occur in some of the sandstones, but no determinable fossils of any kind were obtained.

Character of
beds.

Montana.—This formation on the Athabasca and its tributaries is represented by about fifty feet of alternating sandstones and shales, exposures of which occur along the lower slopes of the Laramie plateaus south of Lesser Slave Lake, and by the upper part (about 700 feet) of the La Biche shales of Lesser Slave River and the Athabasca. The exact junction between the Montana and the Colorado was not definitely

Beds of Mon-
tana age south
of Lesser
Slave Lake.

ascertained owing to the scarcity of fossils, and to the fact that the La Biche shales pass downwards from the Montana into the Colorado without any structural break or lithological change of any kind.

Fossils.

The fossils collected from the Montana on the Athabasca and on Lesser Slave Lake and River include:—

- Pteria Nebrascana*, Meek and Hayden.
- Tancredia Americana* " "
- Protocardia borealis*, Whiteaves.
- Lunatia concinna*, Hall and Meek.
- Anchura Americana*, Meek and Hayden.
- Baculites compressus*, Say.

Montana beds
on Peace
River.

In the Peace River section the Montana is represented by the Upper or Smoky River shales, and possibly by the lower part of the Wapiti River sandstones. These occur south of the district now reported on, but were examined and described by Dr. G. M. Dawson in 1879.* The Smoky River shales are the equivalents of the Upper or Pierre portions of the La Biche shales of the Athabasca sections. They are 200 feet thick, and are described as dark grayish or bluish-black, thin-bedded shales, holding beds of ironstone and in some places large ferro-calcareous nodules. The fossils obtained from the Smoky River shales belong chiefly to the typical Pierre and Fox-hill fauna, and includes such well-known fossils as *Pteria linguiformis*, *P. Nebrascana*, *Nucula cancellata*, *Liopistha undata*, &c., but besides these, specimens of *Scaphites ventricosus*, a typical Benton species were also found.

Dunvegan
beds.

Dunvegan Group.—This name has been applied to a series of sandstones and shales, which are extensively developed along the Peace River valley, from about fifteen miles above the Smoky River Forks, up to the Cañon of the Mountain of Rocks. This part of the river was not visited during the present exploration, but was examined by Dr. Selwyn in 1875, and a description of the formation is given in the Report of Progress, Geological Survey of Canada, 1875-76. In 1879 the lower part of Smoky River was examined by Dr. G. M. Dawson, and the Dunvegan beds were found on it, underlying the Smoky River shales (Pierre), but in greatly diminished volume.†

Character of
Dunvegan
beds.

The character and age of the Dunvegan beds are fully discussed by Dr. Dawson in the report just mentioned, and but little additional information has since been obtained. They consist of grayish and yellowish flaggy and massive sandstones, often false-bedded and ripple-

* Report of Progress, Geological Survey of Canada, 1879-80, Part B, page 122.

† Report of Progress, Geological Survey of Canada, 1879-80, Part B, pages 116-122.

marked, alternating with grayish and dark shales, usually more or less arenaceous, and holding small beds of ironstone and thin seams of lignite. The thickness of the formation rapidly increases going westward towards the mountains, from 100 feet on Smoky River to 600 feet or more at Dunvegan, and nearly 2,000 feet at Table Mountain. The Dunvegan beds have not been detected east of Smoky River, and probably die away soon after crossing that stream, and they are not represented, so far as known, on the Athabasca.
Increase in thickness going west.

The fauna of the Dunvegan formation is remarkable for its varied character, as it contains fresh water shells like *Viripara* and *Corbicula*, brackish water shells like *Corbula* and *Ostrea*, and such a strictly marine genus as *Inoceramus*. This assemblage of fossils, together with the general character of the beds, evidences estuarine conditions and deposition on an oscillating surface.
Fauna of Dunvegan beds.

The Dunvegan formation occupies nearly the same position stratigraphically, as the Belly River series of Assiniboia and Alberta, and may possibly be a continuation of it, but it differs in containing marine fossils, the fauna of the latter so far as known, being confined to fresh and brackish water species. It is also closely allied by its fauna to the Bear River formation of Wyoming, lately described by White and Stanton*. Two of the most characteristic species of the Bear River beds, *Corbula pyriformis* and *Corbicula Durkeii* occur in the Dunvegan formation, and most of the genera are alike. The position of the two formations in the Cretaceous is, however, different, as the Bear River beds are placed by the above writers below the Colorado, while the Dunvegan series overlies that formation.
Position in Cretaceous.

Colorado.—The beds assigned to the Colorado on Peace River are about 1,500 feet thick, and include in descending order, the Fort St. John shales, the Peace River sandstones, and the Loon River shales. The Fort St. John shales are exposed in the Peace River valley for some miles above and below Fort St. John and extend up Pine River nearly to the Forks. They are brought up here by a low anticlinal and disappear in descending Peace River near the mouth of Pine River north, and do not appear again until a point twenty-four miles above the Smoky River Forks is reached. Below this point they are exposed in the banks of the valley all the way to Battle River and beyond, and still further north form the upper part of the Buffalo Head Hills plateau. The Fort St. John shales have a minimum thickness of 700 feet, and consist throughout of brownish and dark grayish to black shales holding calcareous nodules, and in places a notable quantity of ironstone in nodules, lenticular beds and sheets. They are very unfossiliferous,
Colorado beds on Peace River.
Character of Fort St. John shales.

* American Journal of Science, vol. XLIII., p. 91.

as with the exception of a few fish scales, no specimens were found in the numerous sections examined, from the Smoky River Forks northwards. In their outcrop near Fort St. John a species of *Inoceramus*, and *Buchiceras cornutum*, which is most probably an *Acanthoceras* allied to *A. Woolgari*, were found by Dr. Selwyn in 1875.

Characters of
Peace River
sandstones.

The Peace River sandstones underlie the Fort St. John shales, and appear from beneath the latter in descending the river, immediately below the Smoky River Forks, and are then exposed in the banks of the valley down to about three or four miles below Battle River. Exposures are confined entirely to the valley, as the slight southerly dip by which they are affected for some miles below the forks, fails to bring them to the surface of the plateau, and further down they become almost horizontal. The Peace River sandstones consist of heavy massive beds of yellowish and grayish soft coarse sandstones, alternating with bands of thin-bedded sandstones and shales. The massive beds have an occasional thickness of fifty feet or more, and weather into a series of steep cliffs separated by sloping terraces cut out of the shaly bands. Lignite seams occur occasionally, and hard sandstone concretions ranging from a few inches to ten or fifteen feet in diameter form a prominent feature of the formation. In descending Peace River, the Peace River sandstones become more argillaceous, decrease gradually in thickness and at length disappear a few miles below the mouth of Battle River. They occur along Loon River for some miles, nearly due east from the mouth of Battle River, but in diminished volume, and the exposures here mark approximately the northern limits of the formation in this longitude.

Fossils.

Fossils were found throughout the Peace River sandstones, but occur most abundantly near the base of the mountain. The fauna differs from that of the Dunvegan group in being strictly marine. (See list pp. 47-48.)

Loon River
shales.

The Loon River shales, the lowest division of the Colorado or Peace River, consist of about 400 feet of dark grayish to nearly black, soft shales, holding calcareous and ironstone nodules, interstratified with occasional beds of sandstone, impure limestone, and ironstone. Fossil wood was found in considerable quantities, scattered through this formation, and a lignite seam is said to exist some miles above Fort Vermilion, but was not seen. The Loon River shales appear in descending Peace River, about twenty miles above Battle River, and are exposed on the banks of the valley nearly all the way down to the Vermilion Falls. They also occur on the lower part of Loon River, and on Red River. They alternate above with Peace River sandstone, and below appear to rest directly on the

Devonian limestones, although the contact was nowhere seen. The fossils collected from the Loon River shales consist of numerous specimens of *Desmoceras affine*, Whiteaves, *D. affine*, var. *glabrum*, Whiteaves, and *Hoplites Canadensis*, Whiteaves.

The Colorado, in the parallel Athabasca section, resembles in its general features that on Peace River, but differs in detail. It includes, according to present evidence, the lower part of the La Biche shales, the Pelican sandstone and shale, the Grand Rapids sandstone, and the Clearwater shale in all about 930 feet of strata.

The lower part of the La Biche shales corresponds in a general way with the Fort St. John shales.

They consist of soft dark grayish to black clay shales, differing in no respect lithologically from those forming the upper part of the formation, but have been separated from them on fossil evidence.

The upper part of the La Biche shales holds a characteristic Pierre and Foxhill fauna, while in the lower part *Ostraea congesta*, *Desmoceras Athabascense*, Whiteaves, and *Acanthoceras Woolgari*, Mantell, occur. The La Biche shales are succeeded in descending order by the Pelican sandstone and shale, and the Grand

Colorado terranes on the Athabasca.

Biche shales.

Pelican sandstone and shale.

Rapids sandstone, the probable equivalents of the Peace River sandstone. The Pelican sandstone is forty feet thick, and consists of a massive bed of soft grayish sandstone, which becomes hemitiferous above in some places. No fossils were obtained from it.

The Pelican shale is ninety feet thick, and is argillaceous throughout. It alternates above with the Pelican sandstone, and appears to die out toward the northwest, as the thickness on Moose River is only a few feet, and it was not recognized at all on the north end of the Birch Mountain. The

Grand Rapids sandstone is 300 feet thick, and is composed of massive cliff-forming beds of yellowish and grayish sandstone, separated by

Grand Rapids sandstone.

bands of thinly-bedded sandstones and shales. Lignite seams appear in places, and large, rounded sandstone concretions occur so abundantly in some of the beds, that they form a considerable portion of the substance of the formation. Fragments of Ammonites and other marine shells were found in the Grand Rapids sandstone, but no specimens perfect enough for determination were obtained.

The Clearwater shale, the lowest division of the Colorado on the Athabasca, holds a considerable proportion of sandstone interstratified

Clearwater shale.

in thin beds with the shales, and also a green sand bed, which is probably glauconitic. Mr. Ferrier, Lithologist to the Survey, reports on this rock as follows:—"After a careful examination of this section and comparing it with a series of typical glauconitic rocks from the Tertiary of various foreign localities, I can find no difference in character between it and them. The mineral agrees in all its characters

Glauconitic bed.

Character of
Clearwater
shale.

with typical glauconite. Zirkel states* that the mineral, glauconite, is only single refracting. This must be an error, as the glauconite in all the slides examined was decidedly double refracting, but in weak colours. It has a slight resemblance to some varieties of Serpentine." Ironstone in nodules and beds is also present, and fossil wood occurs occasionally. The Clearwater shale has an average thickness of 275 feet, and occupies approximately the same stratigraphical position as the Loon River shale on Peace River, and the lower part of the Peace River sandstone. A number of fossils were collected from it, lists of which are given on pp. 31-32. The following list by Mr. Whiteaves includes all the fossils collected from the various subdivisions of the Colorado. As some of the species are undescribed, only the generic names of these can be given.

PELECYPODA.

- Lima* sp.
- Pecten* sp.
- Camptonectes* sp.
- Modiola*, allied to *M. tenuisculpta*, Whiteaves.
- Nucula (Acila)* sp.
- Yoldia*, like *Y. Evansi*, Meek and Hayden.
- Trigonia* sp.
- Protocardium* sp.
- Callista tenuis*, Hall and Meek.
- Goniomya* sp.
- Mactra (Cymbophora)* sp.
- Teredo* sp.

GASTEROPODA.

- Lunatia* sp.
- Cinulia* sp.

CEPHALOPODA.

- Desmoceras affine*, Whiteaves.
- " " var. *glabrum*.
- Desmoceras Athabascense*, Whiteaves.
- Hoplites McConnelli* "
- Acanthoceras Woolgari*, Mantell.

Dakota age of Tar sands.—The Tar sands underlying the Clearwater shale have been assigned to the Dakota, entirely on lithological and stratigraphical evidence, as no fossils were obtained from them. They rest on the Devonian limestones, and occur in the same position as the sands of undoubted Dakota age, which outcrop along the eastern edge of the

* "Die mikroskopische Beschaffenheit der Mineralien und Gesteine," Leipzig, 1873, p. 487.



R. G. McConnell, Photo, 1890.

VIEW ON ATHABASCA RIVER.

SHOWING TAR SANDS OVERLYING DEVONIAN LIMESTONES.

Cretaceous in Manitoba, and south of the International Boundary in Minnesota. They consist of an almost homogeneous mass of tar-cemented sands, ranging in texture from a coarse silt to a grit, and vary in thickness, where fully exposed, from 140 to 220 feet. They contain occasional thin beds of ironstone, and in two places lenticular beds of quartzite were noticed. Fragments of fossil wood occur throughout the formation. The Tar sands occur along the Athabasca valley from Boiler Rapid to a point about nine miles below the mouth of Calumet River, a distance of about ninety miles. West of the Athabasca they are soon concealed by the overlying divisions of the Cretaceous, but are exposed for some miles along the valleys of the tributary streams. They were not found on Peace River. East of the Athabasca they occur in heavy sections on the Clearwater, Pembina and High-bank rivers, but on Muskeg and Firebag rivers the sections are small, and the greater part of the material in this district has evidently been planed away by glacial action.

Character of
Tar sands.

GLACIAL GEOLOGY.

Boulder clays and the stratified sands and gravels by which they are usually accompanied, mantle the greater part of the region dealt with in the present report, so heavily and universally, as to conceal the older rocks nearly everywhere, except in the deep valleys of the main drainage channels, and along the escarpments of some of the plateaus. The glacial deposits have not been distributed uniformly, as in some of the old pre-glacial depressions they attain a thickness of 200 feet or more, while on the ridges they become greatly attenuated, and in some places the boulder clay disappears and the superficial deposits are represented only by the modified drift. Their influence in levelling the country has, however, been destroyed to some extent by irregularities in their own deposition, resulting in the production of the rolling type of country which prevails throughout a large part of the region. Another feature directly due to the unequal distribution of the glacial deposits is the number of small lakes and ponds inclosed in shallow land-locked basins in the drift, which are met with throughout the district, and which occur so frequently in some localities as to cover a considerable proportion of the surface. The present lakes and ponds represent only a part of those which originally existed, as many of them have become filled up with sphagnum and converted into muskegs and marshes.

Distribution
of glacial
deposits.

The glacial beds are very uniform in character, and will only require a brief description. On the Athabasca, boulder clays of the ordinary type, usually underlaid by stratified sands and gravels

Glacial beds
on the Atha-
basca.

of the age of the Saskatchewan gravels, are met with, capping most of the sections between the mouth of Lesser Slave River and the Pelican, but from the latter point to the Forks, they were seldom observed, and the glacial deposits are represented chiefly by a thick bed of gravel and boulders of all ages, piled confusedly together, accompanied in some places by sands and clays. Below the Forks the glacial beds increase in importance, and from Calumet River to the delta, they form the principal feature in the geology of the Athabasca valley. They consist in this portion of the valley, of boulder clays, underlaid by stratified sands, and overlaid by a bed of coarse sand and pebbles. The lower sands are never fully exhibited, but show an exposed thickness in different sections of from thirty to 100 feet. They are unconsolidated, and in some places are interstratified with beds of gravel and layers of rolled sandy nodules, cemented by tar. The sands are characterized in many of the sections by a peculiar reddish colour, but in other places yellowish and brownish tints prevail. They are exposed in numerous sections on both sides of the valley, nearly to the head of the delta.

Glacial beds well represented below the Forks.

Red boulder clay.

The boulder clay is divided by a difference in coloration into two parts. The lower division is characterized by a distinct reddish tint, while the colour of the upper part is usually a dark gray. The line between the two boulder clays, while often indistinct, is sometimes clearly drawn, and in one place, a short distance below the mouth of Firebag River, they are separated by stratified sands. The section at this point in ascending order, consists of :—

	Feet.
Soft sands, holding layers of sandy tar nodules	50
Red boulder clay	20
Sands, similar to those below boulder clay	20
Dark boulder clay	2
Sands and gravels, partly concealed	15
<hr/>	
	107
<hr/>	

Section below Firebag River.

A mile below the last section, the glacial deposits consist of sixty feet of yellowish and brownish sands, overlaid by twenty feet of reddish clay, holding scratched and polished boulders, above which comes ten to fifteen feet of coarse sands and gravels, part of which is saturated with tar. The red boulder clay is well exposed in the vicinity of Red Earth Creek, and was traced down the river to a point about ten miles below Pointe aux Trembles.

Beds overlying boulder clay.

The boulder clay is overlaid in most places by sands and gravel and pebble beds, a notable feature of which is the amount of tar they con-

tain. The tar in these beds is not distributed uniformly like that in Tar in glacial beds. the Tar sands of the Cretaceous, but occurs in irregular patches, from a few feet to 200 feet in length, and from a few inches to five or six feet in thickness. The tarry patches, as a rule, immediately underlie the surface, and are confined to the coarse beds. The tar is in a soft condition, and the percentage is as high as in the most saturated portions of the Tar sands of the Cretaceous. The tar in these beds is mixed with fragments of lignite and shale, and appears to have been derived from the Tar sands of the Cretaceous and transported to its present position in some way not fully understood. It has not ascended from below, as no trace of it was observed in the underlying beds, and the compact boulder clays, when present, would necessarily stop its upward flow. Tarry masses of sand and gravel occur at intervals, underlying the surface down to a point about twelve miles below Pointe aux Trembles. Below this point the cut banks show only stratified sands, interbedded in places with layers of rolled tar nodules.

The stratified sands and gravels, both below and above the boulder clay in the lower part of the Athabasca valley, are evidently lacustrine in origin and were doubtless deposited along the southern margin of the greatly extended Lake Athabasca of the Glacial Period. The upper sands extend down to and form largely the present shores of the lake, except when they are covered by the more recent delta deposits.

The Athabasca, in the lower thirty miles of its course cuts through its own delta, and beds of this age, although partly the product of Peace River, extend west of the Quatre Fourches River to Peace River and beyond, and underlie the wide plain west of Lake Athabasca, on which are situated the separated portions of the lake known as Lakes Claire and Mammawee, together with numerous other nameless sheets of water.

In the plains between the Athabasca River and Birch Mountain, Glacial beds and on the eastern slopes and summit of the latter, the boulder clay, as shown by the Moose River section, attains an exceptional development, in some places being fully seventy-five feet thick. The lower sands and gravels appear to be absent here, but stratified gravels were found in one exposure alternating in thin beds with the boulder clay. West and south-west from the Birch Mountains, the rolling plains stretching towards Lesser Slave Lake and Peace River, are everywhere drift-covered but full sections are seldom seen, except near the mouths of the streams flowing into the two trunk rivers, as owing to the immature condition of the drainage system, the valleys are seldom excavated sufficiently deep to reach the older rocks, and in most cases they are only a few feet deep.

Boulder clay
in Peace
Valley.

Red clays.

Direction of
movement of
Great Glacier.

Distribution
of red boulder
clay.

In the deep valley of Peace River, boulder clays often associated below with stratified beds, are found overlying the older rocks in most of the sections examined. In the upper part of the valley the boulder clay is of the normal type, but for some miles above Fort Vermilion, down to the Vermilion Falls, and up the Red and Loon Rivers for a considerable distance above their mouths, reddish clays are intermixed in patches and bands with the ordinary boulder clay. The reddish clays are occasionally pure, but as a rule they carry boulders, are more or less arenaceous, and are only distinguished from the associated clays by their colour.

The red boulder clay affords a means of tracing the general direction of movement of the Great Glacier, superior even to that afforded by glacial striæ, as the latter are apt to be deflected locally by the contours of the country. On the Athabasca these clays are found, from above Red Earth Creek down to a point about ten miles below Pointe aux Trembles, below which the boulder clay is covered by more recent deposits. On Peace River the red boulder clay occurs on the lower parts of the Red and Loon Rivers, and along the Peace River from the mouth of Red River up to Fort Vermilion and beyond. A line running 12° N. of W. from Pointe aux Trembles to the mouth of the Loon on Peace River, would pass through the centre of the red boulder clay belt. The glacier travelling along this line must have moved up the eastern slope and over the summit (1,500 feet) of Birch Mountain. That it did so, is further shown by masses of Tar sands occurring in the drift on the summit of this plateau, which could only have been derived from the exposures in the Athabasca valley, many hundreds of feet lower down. The nearly easterly movement of the glacier west of Athabasca and Great Slave Lakes, taken in connection with the southerly movement south of Lake Athabasca, and its northerly movement on the Mackenzie, shows that the ice must have radiated from a centre situated somewhere between the eastern ends of these two lakes and Hudson Bay.

ECONOMIC GEOLOGY.

Gold on Peace
River.

Gold.—Gold was found in many of the bars along Peace River, and in several places in sufficient quantities to deserve attention. Three miles above the mouth of Battle River, a large bar nearly a mile long, on the left bank, was examined, from which we obtained fifteen to twenty *colours* of fine gold, by washing a few handfuls of the mixed gravel and sand in an ordinary frying pan. We tried the bar at several points, and always with the same result. A small stream descends from the plateau on the opposite side of the river, and by

leading its waters across the river, which is here about 1,000 feet wide, the bar might be easily and inexpensively worked on a large scale. Twelve miles further up the river, another bar was examined, which yielded from twenty to forty *colours*, when washed in the same way. Numerous other bars occur in this portion of the river, which would probably give as good results as those examined.

The presence of fine gold in some quantity in the bars above the mouth of Battle River is probably due to the diminution in the strength of the Peace River current which takes place here, and its consequent loss of transporting power. The same fact is shown in the gradual substitution of sand bars for gravel bars which occur at the same point.

Besides the gold on Peace River, two *colours* were also washed out of a bar on Loon River, an eastern tributary of the Peace.

Iron.—Clay ironstone in nodules and thin beds, is of universal occurrence in the Cretaceous shales of the region, but is especially abundant in some of the outcrops of the Fort St. John shales on Peace River, between Battle River and the mouth of Smoky River. The ironstone here, owing to the rapid erosion of the soft shales has been silted out, and in many places forms thick accumulations at the foot of the cliffs lining the valley, some of which may prove to be of economic value. The Pelican sandstone on the Athabasca is usually capped with a bed of hemitiferous sandstone varying in thickness from a few inches to four or five feet. A specimen of this rock was examined in the laboratory of the Geological Survey, and found to contain 12·4 per cent of metallic iron.

Lignite.—Lignite was found in the Peace River sandstones on the Peace River in several places, but in seams too small to be workable. It also occurs in the plateaus south of Lesser Slave Lake. In one section at the latter place, four seams ranging in thickness from one to four feet, besides a number of smaller ones were found, distributed through about 1,000 feet of sandstones and shales. Drift lignite was also found in Marten River near the base of Marten Mountain, but it was not traced to its source. On the Athabasca, the Grand Rapids sandstone is lignitiferous, some of the seams being from four to five feet thick, but the quality is usually inferior. Several small seams also occur imbedded in the Tar sands.

Salt.—Mineral springs holding considerable percentages of sodic-chloride occur on the Athabasca at La Saline, twenty-eight miles below the Forks, and about two miles above the mouth of Red Earth Creek (see p. 36). Samples of the water have been analysed in the Survey laboratory by Mr. Wait, with the following result.

Grains of saline constituents in one imperial gallon—at 60° F.

	Red Earth Creek.	La Saline.
Chloride of potassium	4·89	121·87
" sodium	860·28	4,475·69
" magnesium		77·25
Sulphate of lime	228·10	394·12
" magnesia	43·21	85·05
Total	1,136·48	5,153·98

Specific gravity at 60° F. 1·012 1·052

Saline springs of small volume also occur on the Pembina River and at Tar Island on Peace River.

Gypsum at
Peace Point.

Gypsum.—Gypsum is deposited in small quantities by the mineral springs at La Saline, and it also occurs on Peace River between Bouillé Rapid and Peace Point, where beds ten to fifteen feet in thickness are said to exist. Blocks of gypsum several feet in diameter were found on Peace River above its confluence with Loon River, and on Red River, a few miles above its mouth. They have probably been derived from the Peace Point exposures, and carried up the valley of the Peace River by ice during the Glacial Period.

Gas springs
on the Atha-
basca.

Natural Gas.—The most important natural gas spring in the district occurs on the Athabasca at the mouth of Little Buffalo River. The gas here forces its way up from the Tar sands, through 250 feet of the Clearwater shales and issues from the surface in numerous small jets distributed over an area, fifty feet or more in diameter. Some of the jets burn steadily when lighted, until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed on the left bank of the Athabasca about thirteen miles below the mouth of the Pelican River. The volume of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sandstone which here overlie the Tar sands. Escaping jets of gas were also noted at several points further up the river, but these were mostly small, and may possibly be due to decaying vegetable matter. On Peace River natural gas issues in small quantities from the Tar spring on Tar Island. The natural gas springs have less value in themselves at present, than in the indications they afford of the existence of petroleum beneath.

Gas spring on
Tar Island.

Age of Tar
sands.

Bitumen.—The Tar sands, the principal bitumen bearing formation of the district, are described in a preceding part of the report. This unique formation is of Dakota age, and constitutes in this region

the basal member of the Cretaceous series. It rests unconformably on the Devonian, and is exposed overlying the latter along the valley of the Athabasca for a distance of ninety miles. Lithologically it may be described as a soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the subjacent limestones. The boundaries of the Tar sands were only precisely defined at a few points, but they were estimated to have a minimum distribution of fully 1,000 square miles, where either completely uncovered, or buried beneath a part of the overlying Clearwater shale on the highlands, and exposed in the river valleys. They vary in thickness where the section is complete, from 140 to 225 feet. The bitumen is unequally distributed through the sands, in a few places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. The following calculation, which is extracted from the Summary Report for 1890, although it can only be regarded as an approximation, yet will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region.

"An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell, gave by weight :—

Bitumen	12·42
Water (mechanically mixed).....	5·85
Siliceous sands.....	81·73

"A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117·5 lbs. This figure multiplied by the percentage of bitumen 12·42 gives 14·59 lbs. as the amount of bitumen present in a cubic foot, or $\frac{14\cdot59}{6\cdot8} = 22\cdot9$ per cent in bulk. Taking the thickness at 150 feet, and assuming the distribution as given above at 1,000 square miles, the bituminous sands in sight amount to 28·40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although it is probably rather high 22·9 per cent in bulk, or 6·50 cubic miles is bitumen. The amount of petroleum which must have issued from the underlying limestones to produce 6·50 cubic miles, or by weight approximately 4,700,000,000 tons of bitumen, cannot now be estimated, as the conditions of oxidation and the original composition of the oil is unknown. It must, however, have been many times greater than the present supply of bitumen."

The commercial value of the Tar sands themselves, as exposed at the surface, is at present uncertain, but the abundance of the material, and the high percentage of bitumen which it contains, makes it probable that it may, in the future, be profitably utilized for various purposes, when this region is reached by railways. Among the uses to which

it is adapted, may be mentioned roofing, paving, insulating electric wires, and it might also be mixed with the lignite which occurs in the neighbourhood, and pressed into briquettes for fuel.

Probability of finding oil.

The Tar sands evidence an upwelling of petroleum to the surface unequalled elsewhere in the world, but the more volatile and valuable constituents of the oil have long since disappeared, and the rocks from which it issued are probably exhausted as the flow has ceased. In the extension of the Tar sands under cover the conditions are different, and it is here that oils of economic value should be sought. In ascending the Athabasca, the Tar sands are overlaid at Boiler Rapid by a cover of shales sufficient to prevent the oil from rising to the surface, and in ascending the river, this cover gradually thickens. The geological attitude of the shales is not the most favourable, as the beds dip away from the outcrop at the rate of five to ten feet to the mile, and it is possible that a part, or even the whole of the oil may have flowed northwards and eastwards through the sands, and escaped where these come to the surface. It is unlikely however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the beds themselves may serve to inclose reservoirs or inverted basins of large capacity. It is also possible that the sands at their outcrop, may by the deposition of tarry substances be plugged tightly enough to prevent further egress. Favourable indications of the presence of oil in the vicinity of the Athabasca, are also afforded by the existence of the natural gas springs referred to on a previous page.

Drilling desirable.

The question of the continuity of the Tar sands and their petroliferous character under cover, can, however, only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. At the mouth of Pelican River the Tar sands are probably covered by about 700 feet of strata, and this amount increases as the river is ascended. At the Athabasca Landing, if the formation extends to that point, it probably lies at a depth of from 1,200 to 1,500 feet below the surface, but the distance of the Landing from the outcrop of the Tar sands, and the variability in the thickness of the Cretaceous formations make it impossible to give more than a rough estimate.

Indications of oil on Peace River and other places.

Indications of the presence of oil in the district is not confined to the Tar sands, as on Peace River and Lesser Slave Lake inspissated bitumen was found in a number of places lining cracks in nodules, and at Tar Island in Peace River, small quantities of tar are brought to the surface by a spring. Tar springs are also reported from several

other points, but their existence lacks verification. North of this district tar occurs at intervals in the Devonian limestones exposed along the valleys of Slave River and the Mackenzie, all the way to the Arctic Ocean.

**Logical Survey Department
Canada**

A geological cross-section diagram showing rock units from Devonian to Cretaceous. The diagram includes labels for various rock types, thicknesses, and specific locations like Fort Verde Shale, Fort Verde Shale, and Fort Verde Shale.

ON ALONG THE ATHABASCA VALLEY FROM ATHABASCA LANDING TO FORT MCMURRAY

Baldwin, Brown and Ladd, Slave Block, Section

1. 266

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

NORTH - WESTERN MANITOBA

WITH PORTIONS OF THE ADJACENT DISTRICTS OF

A. NIBOIA AND SASKATCHEWAN

BY

J. B. TYRRELL, M.A., B.Sc., F.G.S.,



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY

1892

To ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

SIR,—I beg to present herewith my report on North-western Manitoba, and portions of the adjacent Districts of Assiniboia and Saskatchewan, accompanied by two copies of a map on the scale of eight miles to one inch, one showing the geology of the region, and the other the distribution and character of the forests.

The collections made during the course of the exploration have for the most part been described in other reports and papers. For gratuitous assistance in the description of these collections we are indebted to Dr. D. Rüst, of Hanover, Germany; Dr. H. A. Nicholson, of Aberdeen, Scotland; Prof. T. Rupert Jones, of London, England; Sir William Dawson, Prof. D. P. Penhallow and Prof. B. J. Harrington, of McGill College, Montreal.

We are also indebted to the various officers of the Hudson's Bay Company for much assistance rendered during the course of the exploration, but especially to Mr. David Armitt, of Manitoba House, who did everything in his power to promote the welfare of the expedition.

I have the honour to be, sir,
Your obedient servant,
J. B. TYRRELL.

GEOLOGICAL SURVEY OFFICE, 6th June, 1892.

NOTE.—The bearings throughout this report are given with reference to the true meridian.





NORTH - WESTERN MANITOBA

WITH PORTIONS OF THE DISTRICTS OF

ASSINIBOIA AND SASKATCHEWAN

INTRODUCTION.

The present report, with the accompanying maps, is the result of Date of ex-explorations carried out during the summers of 1887 and 1889, and ploration. portions of those of 1888 and 1890.

On account of the magnificent resources of this country in dairying, Preliminary lumbering and agriculture, and also on account of the long continued ill-report. health of the writer caused by an attack of typhoid fever contracted in the northern part of Lake Manitoba, it was thought advisable to publish a preliminary description of the region in the Annual Report Geological Survey, vol. III., in which a few of its main characteristics were commented on.

Throughout the progress of the survey, Mr. D. B. Dowling, B.A.Sc., Assistance has acted continuously as my assistant and has performed a considerable portion of the topographical work that it was found absolutely necessary to prosecute in order to designate intelligently the geological features of this hitherto almost unknown region. To him is also due the credit for any excellence that the maps possess from a cartographical stand-point. The projection was laid down by Mr. Scott Barlow, chief draughtsman, and the proofs were carefully inspected by him.

In the preparation of the map, it has been found much more satisfactory to represent differences of elevation by contour lines, rather than by hachuring as has been customary up to the present in the maps published by this department, since by this method the character of the escarpment running north-north-westward through the province of Manitoba can be beautifully brought out. On the other hand, it has been impossible thus to represent many of the steep, but comparatively low slopes.

Maps.

As a basis for the preparation of the present map the surveys made by the Dominion Lands Branch of the Department of the Interior have been used wherever practicable. These include surveys of townships and township outlines in the southern portion, all of which are marked in full lines; the western boundary of the province of Manitoba as far north as the north side of township 36; a meridian township outline between ranges 18 and 19 on the First System of Survey, run on the ice across Lake Winnipegosis to Cedar Lake; a traverse survey of Lake Manitoba (corrected by transverse lines at several points); a traverse survey of Lake Winnipegosis from Meadow Portage around the west shore to the mouth of Overflowing River, and surveys of Shoal River, Swan Lake, and Swan and Overflowing Rivers for a few miles above their mouths; a survey of the Saskatchewan River (corrected for longitude by connecting it with the meridian line running southward across Lake Winnipegosis). The surveys of the old line of the Canadian Pacific Railway have been of much value, especially in furnishing reliable bases of elevation. The Manitoba and North-western Railway has furnished similar information for the south-west corner of the sheet. Besides these lines, surveys of Waterhen River, and Meadow and Mossy Portages were made in connection with the Canadian Pacific survey. Indian reserves have been incorporated throughout, as well as several surveys of timber limits in the northern portion of the Duck Mountains.

The following statement of the surveys performed during the course of the present exploration is essentially an abridgement from the Summary Reports of the Director in the "Annual Reports" of the Geological Survey Department, vols. III. and IV.

Exploration,
1887.

Starting from Brandon on the 15th of July, 1887, we drove northward to Strathclair, and thence made an odometer survey of the trail up the Little Saskatchewan River to its source in Lake Audet, across the summit of Riding Mountain and down the Vermilion River to Lake Dauphin. From this trail, paced surveys were made of the beds of Ochre River and Edwards Creek, the banks of these streams being either too swampy or too much obstructed by fallen timber to admit of following them even on foot.

Lake Dauphin
Plain.

An odometer survey was then made northward across Wilson River to Valley River, a track survey at the same time being made of Wilson River and its vicinity. North of Valley River one of the rounded gravel ridges, known to the Indians as "Pitching Ridges," was followed, first with a buckboard and odometer, and afterwards on horseback as far as Fork River, a fairly accurate sketch-map being at the same

time made of the eastern face of Duck Mountain. Finding that progress would be very slow north of Fork River, we returned to Valley River and made an odometer survey of the cart trail leading westward along this stream, reaching Shell River through the deep glacial valley that separates the Duck from the Riding Mountain. From Shell River the trail was followed and surveyed over the high ground southward to the village of Russell, a terminus of one of the branches of the Manitoba and North-western Railway. From Russell, a similar survey was conducted across Silver, Bird Tail and Arrow Creeks to Shoal Lake, and thence to Little Saskatchewan River, returning by a more northern route to the point of starting.

From Russell we proceeded northward with buckboard and carts Shell River, to Assessippi, on Shell River, from which point the vehicles were sent round to meet me higher up the river, while with saddle and packhorses I examined the lower part of the valley, and rejoined the carts about the south line of township 26. We then continued up Shell River to within three miles of the confluence of the north and east branches, generally in the bottom of the wide, deep valley, but sometimes where it was impossible, without great delay, to ford the stream, we were obliged to climb to the top of the bank. On the way, however, we left Shell River for a time and turned eastward on an Indian cart trail to Angling Lakes, where Coté's band of Indians have several houses in which they spend the winter, being here in the centre of their hunting grounds. From this village, then quite deserted, a track survey was made of the stream that flows southward out of the largest and most easterly of the Angling Lakes till it was found to flow into the valley that separates the Duck from the Riding Mountain. It was found to be the main branch of Valley River. Two pack trails leading northward from the Indian village were also examined, one being found to lead up the east branch of Valley River to its source, and the other to Gull Lake which belongs to the drainage area of Shell River.

Angling Lakes.

Returning to this latter river, we were obliged to leave the carts at a point three miles below the confluence of the north and east branches, and to use packhorses in continuing the survey towards the sources of some of the small streams tributary to the main river. Returning to the carts we followed and surveyed an Indian cart trail westward across Big Boggy and Little Boggy Creeks, till it joined the old Pelly cart trail at the Indian village on Cote's Reserve. We then followed and located the latter trail northward to Fort Pelly, where we arrived on the 22nd of September.

Swan River.

Having here obtained sufficient supplies to last till the end of the season, we followed a cart trail to the north-east, keeping south of Swan River for about forty miles, or till we reached the "Square Plain," making an odometer survey throughout the distance. I, however, branched off from this trail, and with packhorses followed a trail up Rolling River, till the stream became very small and was flowing in a shallow valley through a country that appeared to be one interminable swamp. As the country was impassable for horses, I returned and made a paced survey down the bed of the stream to a short distance below the crossing of the old location of the Canadian Pacific Railway, where the river again flows in a defined but winding channel through a marshy, level tract of country.

Duck Mountain.

Returning to Square Plain, Swan River was crossed and followed on its northern bank down to the mouth of Oak Creek, where the carts were again left, and with pack and saddle horses a track survey was made around the north end of Duck Mountain, following, during part of the distance, conspicuous gravel ridges that extend along the eastern face of the escarpment, at least as far north as the valley of Swan River. In returning, the north-east point of the Duck Mountain was crossed, and also the head-waters of North and South Duck Rivers and Pine River. Then passing around the north end of Big Lake, in which Rolling River takes its rise, the head of Favell River was reached. This river was then followed on a northward course to near its junction with Rolling River, whence we returned to the carts at the mouth of Oak Creek.

While I was engaged as above described, Mr. Dowling was making pace and track surveys of Swan River and of the country lying north of it in the vicinity of the camp.

Swan River Trail.

Below Oak Creek an odometer survey was made of the trail down to Swan Lake, and the river was followed on foot in many places, where there was any possibility of exposures of the underlying rocks being met with. From Swan Lake the party returned to Fort Pelly by the old Hudson Bay Company's cart trail on the north side of Swan River, at the same time making an examination of the southern face of Thunder Hill.

The village of Russell was reached and the season's work completed on the seventh of November.

Barometer readings.

Readings were taken regularly three times a day from a mercurial barometer, and numerous intermediate readings were taken from two aneroids. These were compared with readings taken from a standard mercurial at Minnedosa, the height of the cistern of which is 1,689 feet. Known points were also taken along the old Canadian Pacific

railway survey line, and barometer readings at these points were compared with simultaneous readings at many surrounding places.

On the 13th of June, 1888, I left Winnipeg for Portage la Prairie, where Mr. W. R. Baker, General Superintendent of the Manitoba and North-western Railway, kindly ordered a railway velocipede to be placed at my disposal. With its assistance all the cuttings on the railway between Minnedosa and Langenburg were examined, as well as the material thrown out of the wells at and between the different stations.

Returning from Minnedosa to Westbourne we paddled down White Mud River to Totogen, and from there coasted along the west side of Lake Manitoba to Manitoba House. The east side of the lake was next examined from Manitoba House to Fairford, and the Fairford River was descended to its mouth in Lake St. Martin.

A survey was made of this latter lake by Mr. Dowling with a compass and floating boat-log, while the writer travelled on foot into the wooded country to the west of the lake for the purpose of examining and locating a reported deposit of gypsum, after which a careful geological examination was made of the shores of the lake itself.

Returning to Lake Manitoba, its north shore was examined, and any outlying islands were surveyed, as far as the mouth of Waterhen River, and this river was explored up to Waterhen Lake.

From Waterhen Lake the writer returned to Manitoba House, and the next eighteen days were spent in company with Mr. J. F. Whitcaves, Palaeontologist of the Geological Survey Department, in making a full collection of fossils from the exposures of Devonian rocks around the shores of Lake Manitoba.

In the mean time, Mr. Dowling surveyed the east shore of Lake Winnipegosis with a compass and micrometer as far as Mossy Portage, and the north shore with a transit and micrometer from the meridian outline near Mossy Portage to the mouth of Overflowing River, there connecting with the traverse of the west side of the lake made by the Dominion Lands Branch of the Department of the Interior two years before.

He next surveyed with compass and micrometer the Overflowing River for thirty-seven miles up from its mouth, the Red Deer River up to the lake, which was found to have an area of a hundred square miles, and the river for twenty-two miles above the lake. He also connected the final point of the Dominion Lands survey of the Swan River with the chain survey of the higher parts of the river on the south-east side of two Indian reserves now abandoned. He also made a survey of many of the islands in Lake Winnipegosis.

Exploration,
1889.

In the spring of 1889 the rivers St. Martin (Little Saskatchewan) and Fairford were ascended from Lake Winnipeg to Lake Manitoba, and Manitoba House was reached on the evening of the 8th of June.

From Manitoba House the lake was crossed to Crane River Narrows, where lines were run to locate some islands more exactly, and to connect the surveys of the opposite sides of the lake. The Waterhen River was ascended to Lake Winnipegosis and the south shore of this lake examined to the mouth of Mossy River, and at the same time a survey was made of Snake Island, and the other islands in its vicinity.

Mossy River.

A micrometer and compass survey was made of Mossy River, and the shores of Lake Dauphin were run in with the floating boat-log. From Mossy River, the shore of Lake Winnipegosis was closely followed and examined to the mouth of Red Deer River and surveys were made of all the adjoining islands. Shoal River was then ascended to Swan Lake, and surveys were made of the islands in this lake.

Porcupine
Mountain.

From the west side of Swan Lake an examination was undertaken along the foot of the Porcupine Mountain to Kematch River where a good section of the Niobrara and Benton beds was obtained ; meanwhile Mr. Dowling crossed to Bell River, and ascended it to the summit of the mountain, also obtaining a section of the Cretaceous shale and the overlying drift. North of Porcupine Mountain Red Deer River was ascended in canoes to Red Deer Lake. There, horses were obtained from a small band of Indians living at the west end of the lake, and with two men I struck back to Armitt River at the foot of the mountain. From the west bank of this stream two gravel ridges were followed alternately, to near the mouth of the Etoimami River, where they merge into an extensive sandy delta-plain. An old trail was then followed down the north side of Red Deer River back to the lake.

From the mouth of Red Deer River an examination was made of the north and east shores of Lake Winnipegosis, a pace survey was made of the western Mossy Portage, while the eastern Mossy Portage was also carefully examined.

Waterhen
Lake.

From Pine Creek Mr. Dowling returned with the boat to Manitoba House, stopping on the way to make a survey of Waterhen Lake with a compass and floating boat-log. The writer left Pine Creek with a horse and cart, and made an odometer survey of the trail back to a small new Indian village on one of the pitching ridges. From there the ridge was followed north to Duck River, and the deep gorge of North Pine River was discovered and examined. From the Indian village an odometer survey was made southward to the Dauphin settlement, and thence eastward through wooded country to Manitoba House.

In the early summer of 1890 a canoe traverse was made of the Assiniboine River southward from Fort Pelly to Portage la Prairie, and immediately afterwards a survey of the islands and south shore of Cedar Lake was made with a compass and floating boat-log, and the Saskatchewan River was examined from Cedar Lake down to its mouth. At the same time Mr. Dowling examined a small area, hitherto unexplored, on the eastern face of the Riding Mountain south of Lake Dauphin.

The plateau on the summit of Porcupine Mountain was not examined, but its topography has been dotted in from plans and verbal information received from Sakewékochin, John Beardy and Peter More, three Indians living near Swan Lake who hunt and trap in that area.

During the course of the exploration the fossil fauna of western Canada has been very greatly enriched both by the discovery of new species and by the finding of many previously known species which have not before been met with on this continent. Most of these have been identified or described by Mr. J. F. Whiteaves, Palaeontologist of this department. The fossil plants have been kindly determined by Sir William Dawson and Professor D. P. Penhallow, of Montreal; the Radiolaria by Dr. D. Rüst, of Hanover, Germany; the Stromatoporoids by Dr. H. A. Nicholson, of Aberdeen, Scotland; the Ostracoda by Professor T. Rupert Jones, of London, England; and a Cretaceous insect by Professor S. H. Scudder, of Cambridge, Mass., U.S. Specimens of brine from all the principal brine springs in the district were collected and have been analysed by Mr. G. Christian Hoffmann, Chemist of this department; while Professor B. J. Harrington, of Montreal, has kindly analysed the fossil resin collected on the shore of Cedar Lake.

More than two hundred photographs have been taken of places and features of especial interest throughout the region.

HISTORICAL SKETCH.

Secluded position.

North-western Manitoba has, up to the present time, remained comparatively unknown, for since the early part of the present century it has been off the main line of travel either to the Great Plains or to the Athabasca Region. Prior to A.D. 1806, however, the Swan and Red Deer rivers were main channels of the trade of the North-west Company with the Indians of the Plains, and a good cart trail is stated to have existed along the north bank of the latter river through what is now dense poplar forest. Also for many years after the above date Fort Pelly was one of the chief trading posts of the Hudson's Bay Company, and boats of from three to four tons burden annually descended the Swan River, carrying the furs there collected to York Factory on Hudson's Bay.

The following are among the more important recorded explorations that have been made in the region under consideration up to date :

Verendrye,
1739.

Lake Manitoba was first discovered by Chevalier de la Verendrye, who in April, 1739, was sent by his father, Sieur de la Verendrye from Fort la Reine at Portage la Prairie, to look for suitable places to construct forts on Lake des Prairies (Manitoba) and the lower portion of River Paskoiac (Saskatchewan) and to examine the northern end of Lake Winnipeg in order to intercept the trade with the English at Hudson's Bay. Two years later, in October, 1741, another party was sent by Sieur de la Verendrye, under the Chevalier's eldest brother Pierre, to build Forts Dauphin and Bourbon in the district already explored.*

David Thompson,
1797.

In September, 1797, David Thompson, the distinguished geographer of North-western America, crossed Lake Winnipeg from the mouth of Winnipeg River, ascended Dauphin (St. Martin's) River, and entered Manito (Manitoba) Lake. This lake was crossed, the goods were carried across Meadow Portage, and he proceeded to the mouth of the Little Dauphin (Mossy) River. He then traversed Lake Winnipegosis, ascended Shoal River to Swan Lake, and ascended Swan River a short distance to the old fort of the North-west Company on the broad alluvial flat on the north bank of the stream. Here he left his birch canoes and taking horses rode up the valley of Swan River to the trading post on Snake Creek, crossing on his way a wide sandy plain on which he states that "the buffalo sometimes feed in winter." From the Snake Creek Post

*Report on Canadian Archives, 1889, p. 27. Mémoire du Sieur de la Verendrye, in Mémoire et Documents originaux, recueillis et publiés par Pierre Margry. Paris, 1889, pp. 591 & 594.

he turned south to the Assiniboine River, the valley of which he followed to a trading post six miles below the mouth of Little Boggy Creek. He next surveyed the upper waters of the Assiniboine River, after which he set out on his winter journey to the Mandan villages on the Missouri. Mr. Thompson's map, on the scale of about thirteen miles to the inch, is in the possession of the Crown Lands Department of the province of Ontario.*

Alexander Henry, who was afterwards drowned at the mouth of the Columbia River in 1814, spent the winter of 1799–1800 at Fort Dauphin on the lake of the same name, and in 1804, he made a winter journey from Portage la Prairie across Lake Manitoba to Manitoba House.†

In the year 1800 Daniel Williams Harmon, at that time a clerk, and afterwards a partner in the North-west Company, ascended St. Martin's River, crossed Lakes Manitoba and Winnipegosis and ascended the Swan River to the company's trading post. During the winters of 1800–1804 he often travelled up the Swan River valley with a dog team. He speaks of the soil being rich, of there being a garden at the fort, and of salt springs in the vicinity from which salt was obtained.‡

Sir John Richardson, who made several journeys up and down the Saskatchewan in the early part of the present century, states: "We obtained specimens exactly similar to those (limestone) in Lake Winnipeg from Manito-baw Lake, and were informed that it abounds much further to the southward."§

¶He also describes the Scapulae of *Mastodon giganteus* obtained through the exertions of Dr. Rae "from Swan River (properly Swan River District) near the western side of the basin of Lake Winnipeg."

On the first of December, 1836, Thomas Simpson left Fort Garry on his famous journey to the north and crossing Lake Manitoba on the ice reached Manitoba House on the 6th. Thence he coasted the west shore of the lake to Meadow Portage, and travelled on the ice of Lake Winnipegosis to Duck Bay. At Duck Bay he struck inland by a winter trail to Swan Lake, from which he ascended the Swan River

*A Brief Narrative of the Journeys of David Thompson in North-western America by J. B. Tyrrell. Proc. Can. Inst., Vol. VI., pp. 135–160.

†Alexander Henry's Manuscript in the Parliamentary Library in Ottawa.

‡A Journal of Voyages and Travels in the Interior of North America, by Daniel Williams Harmon. Andover, 1820.

§Franklin Journey to Polar Sea. London, 4to. 1823, p. 506. Richardson's Appendix.

¶Zoology of the Voyage of H.M.S. "Herald." London, 4to. 1854, pp. 101–102 and 141–42.

valley to Fort Pelly and going by way of Fort Carlton hurried on to the Mackenzie River.

On his return journey he reached Fort Pelly on the 22nd of January, 1840, and then turned southward by the trail on the west side of the Assiniboine River.

He gives short descriptions of lakes Manitoba and Winnipegosis and mentions the manufacture of salt by "freemen" for sale to the Hudson's Bay Company.*

J. Palliser,
1857.

In October, 1857, Capt. J. Palliser, returning from Fort Carlton, travelled down the trail on the west side of the Assiniboine from Pelly to Ellice, and has left a short general description of that portion of the country.†

S. J. Dawson,
1858.

In May, 1858, Mr. S. J. Dawson left Fort Garry and crossed over to "Manitouba" Lake, on which he embarked, and thence travelled in canoes to the north-west end of "Winnipeg" Lake, crossed the Mossy Portage to Bourbon (Cedar) Lake and descended the Saskatchewan to Grand Rapids. On his return to Mossy Portage he divided the party, giving Mr. Wells, his assistant, charge of one section, while with the other section of the party he ascended the Swan River in canoes to the Pelly Crossing and descended the Assiniboine from Fort Pelly to its mouth.

He gives a description of the character of the shores of lakes Manitoba and Winnipegosis and mentions the occurrence of limestone towards the north end of the latter lake. He also notes the occurrence of mineral springs near the mouth of Swan River, from some of which salt was being made. Swan Lake, and the valley of Swan River are then glowingly described, the latter being correctly stated to be one of the most beautiful tracts of country that he had passed through. A good general description is then given of the valley of the Assiniboine from the Elbow at Fort Pelly to its mouth. He mentions having found float coal on Swan River, and that the Indians report it on Rolling River, Thunder Mountain and Red Deer River.

A. W. Wells,
1858.

Mr. A. W. Wells, who took charge of the second division of the party, measured the length and height of Mossy Portage, giving its length at four miles and eighteen chains and height of Lake Winnipegosis as four feet above Cedar Lake. From Mossy Portage he travelled southward along the west side of Lake Winnipegosis to Mossy River, which he ascended to Lake Dauphin. From Mossy

*Narrative of the Discoveries on the North Coast of America by Thomas Simpson, London, 8vo. 1843, pp. 31-36.

†The Journals, Detailed Reports and Observations relative to the Exploration, &c., by Capt. J. Palliser. London, folio, 1863, pp. 59-60

River he travelled by the north end of Lake Manitoba, whence he descended by St. Martin's River to Lake Winnipeg. He mentions the salt springs on Lake Winnipegos and the occurrence of limestone on Mossy River and Snake Island, the former poor and the latter rich in included organic remains.

After reaching Fort Garry, Mr. Dawson and his assistant proceeded to examine the country between Red River and Lake Superior.

Attached to Mr. Dawson's report is a letter from Mr. E. Billings, dated 21st February, 1859, inclosing others from Messrs. Meek and Hayden, J. W. Dawson and J. R. Jones. This letter states that the fossils collected show the existence of Cretaceous rocks in the Canadian North-west, a fact which had been previously recognized by Dr. Hector in 1857, but which had not yet been made public. The first inclosure identifies the Cretaceous fossils, the second inclosure fossil woods and lignite, and the third a Palaeozoic Ostracod.*

On the 13th of September, 1858, Professor H. Y. Hind accom- H. Y. Hind,
panied by Mr. John Fleming as assistant entered Manitoba Lake from 1858.
St. Martin's River. Crossing this lake, they ascended Waterhen River to Lake Winnipegos and sailed to the mouth of Mossy River, calling at Snake Island and the salt works on the way. Mossy River was ascended with some difficulty and camp was pitched on the south shore of Dauphin Lake, at what was considered the nearest point to Riding Mountain. From the 9th to the 12th of October was spent in ascending the escarpment of Riding Mountain and descending again to the lake, whence Mr. Hind crossed by land on horseback to Manitoba House, while Mr. Fleming went round by the Waterhen River with the boat. While waiting at Manitoba House for Mr. Fleming, Mr. Hind examined the Devonian rocks on Manitoba Island.

From Manitoba House they crossed the lake to Oak Point, whence they returned to Fort Garry. •

The report of this expedition contains records of many interesting geological observations, among which is the first notice of the occurrence of Devonian strata east of the Manitoba escarpment.

In August of the same year, Mr. Fleming had descended the Sas- John Flem-
katchewan from Fort à la Corne to its mouth, on which trip he esti- ing, 1858.
mated the fall of the Grand Rapids at forty-three and a half feet.

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859. This report is accompanied by four maps, two of which are entitled "Sketch of Region explored between Red River and the Great Saskatchewan" and "Thompson's map showing the different tracks of the Saskatchewan and Assiniboine Exploring Expedition" in charge of Prof. H. Y. Hind.

Also the same report in Appendix No. 36 to the Seventeenth Volume of the Journals of the Legislative Assembly of the Province of Canada. Toronto, 4to. 1859.

This has been found to be an under-estimate, as the actual fall is seventy-one feet.

In July of the same year Mr. Dickinson, one of Mr. Hind's assistants, travelled from Ellice to Pelly, up the west side of the Assiniboine, and thence turning southward he followed the west side of the Little Saskatchewan, which he explored for part of its course, afterwards returning to Ellice. He makes no mention of the geology.*

Lord Southesk, 1859.

On the 9th December, 1859, Lord Southesk arrived at Fort Pelly on his return from a hunting trip to the Rocky Mountains. On the 28th of the same month he left this post in a carriage drawn by three dogs and descended the Swan River valley to Swan Lake, which he crossed on the ice, and travelled on the winter trail through the spruce forest to Duck Bay where the Hudson's Bay Company had just established a trading post. From Duck Bay he rode across the ice of Lake Winnipegosis to Meadow Portage and thence down Lake Manitoba to the mission at St. Laurent. He mentions the occurrence of salt springs, and indicates the possibility of springs in the bottom of the lake, as there are places where the ice is always dangerous.†

H. B. Smith,
1873.

In 1873, Henry B. Smith, C.E., made some explorations in this district in connection with the surveys of the Canadian Pacific Railway, with a view to determine the extent and nature of its navigable water-stretches, and the character of the barriers that separate them from each other.

"The Saskatchewan River between Cedar Lake and Winnipeg" is first briefly discussed, then "Mossy Portage between Cedar Lake and Winnipegosis" is described, and a plan and section of it are given. The two lakes are stated to have the same elevation, and the highest point of the portage is a quarter of a mile from Lake Winnipegosis, with an elevation of 93·14 feet above Cedar Lake. The approaches to the portage are also described. "Waterhen River, between Lakes Winnipegosis and Manitoba," is next considered, and a plan and section of the river are given. "Meadow Portage, between lakes Winnipegosis and Manitoba," is stated to have a length of one mile and three-quarters (given in the plan as 1 mile 57 chains 20 links), and the difference in level of the two lakes is stated as 18·73 feet, the greatest elevation being ten feet above Lake Winnipegosis. The approaches to this portage are also described. "Partridge Crop and

*Reports of Progress, together with a Preliminary and General Report on the Assiniboine and Saskatchewan Exploring Expedition by Henry Youle Hind, M.A. Appendix No. 36 to the Journals of the Legislative Assembly. Toronto. 4to. 1859.

†Saskatchewan and the Rocky Mountains, by Earl of Southesk. Edinburgh. 8vo. 1875.

Dauphin (St. Martin's) rivers, between lakes Manitoba and Winnipeg" are next discussed, and their depth and breadth given in several places.*

In the summer of 1874, Dr. R. Bell, of the Canadian Geological Survey, travelled with carts from Fort Garry to Fort Pelly, going by way of Fort Ellice and the trail on the west side of the Assiniboine River. From Fort Pelly he examined the eastern trail southward to Big Boggy Creek, and the valleys of Big Boggy Creek and Shell River in parts of their course. Returning to Fort Pelly he rode down the Swan River valley on the trail north of the river to a point four miles above the mouth of Rolling River where he found the pyritiferous sandstone that has since been determined as representing a horizon about the top of the Dakota formation. Returning again to Fort Pelly he embarked in a skiff on the Assiniboine and followed its windings as far as Fort Ellice. From Fort Ellice he crossed to the south end of Lake Manitoba and proceeded up the west side of the lake to the Narrows, and thence across to Fairford at the discharge of the lake. From Fairford he descended the Fairford and St. Martin's (Little Saskatchewan) rivers to Lake Winnipeg.

Throughout this distance exposures of Cretaceous shales were noted on the banks of the Assiniboine, and Devonian limestones at two places on Lake Manitoba, but no fossils were collected in either case.†

Dr. J. W. Spencer, acting as Dr. Bell's assistant in 1874, examined the lower portion of Shell River, and descended Swan River in a small boat from the Pelly crossing to its mouth, branching off in one place to climb to the top of Thunder Hill. From the mouth of Swan River he crossed Swan, Winnipegos and Manitoba lakes to Oak Point, whence he returned to Fort Garry.

In the Swan River valley, and on the face of Thunder Hill and Porcupine Mountain Cretaceous beds were observed, and specimens collected from the former locality were determined by Dr. George M. Dawson, on the evidence of the contained fossil foraminifera, to be of Niobrara age. Devonian rocks were also noticed on the shores of the various lakes passed through, and some typical fossils were collected from them or from loose masses of rock in their vicinity.‡

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, Winnipegos and the River Saskatchewan at Cedar Lake. From reports of surveys made by Henry B. Smith, C.E., in 1873. Appendix O. C.P.R. Report, 1874, pp. 259-262, with maps and profiles on sheet No. 11, Ottawa, 1874.

†Report on the country west of Lakes Manitoba and Winnipegos by Robert Bell, C.E., F.G.S. Geol. Survey of Canada, Rept. of Prog., 1874-75, pp. 24-56. Montreal, 1876.

‡Report on the country between the Upper Assiniboine River and Lakes Winnipegos and Manitoba by Joseph William Spencer, B. Ap. Sc. Geol. Survey of Canada, Rept. of Prog., 1874-75, pp. 57-70. Montreal, 1876.

G. C. Cunningham, 1874.

In the summer and autumn of 1874, Granville C. Cunningham located the old Canadian Pacific Railway line from Mossy River to the crossing of Snake Creek, around the north-east angle of the Duck Mountain. He gives a short, but clear description of the character of the country passed through, mentioning the occurrence of gravel ridges in several places.*

Swan River bore, 1875.

In the summer of 1875 Mr. Fairbank, of Petrolea, under contract with the Geological Survey of Canada, sank a bore-hole in the valley of Swan River close to the old Mounted Police barracks. A depth of 501 feet was reached, and the rocks throughout were found to be of Cretaceous age.†

J. Macoun, 1881.

In June, 1881, Prof. John Macoun, now of the Geological Survey Department, sailed northward across Lake Manitoba, ascended Waterhen River, and traversed the whole length of Lake Winnipegosis, reaching Shoal River House on the seventh of July. Here he built a boat with which he ascended Red Deer River to the forks, turned southward into Etoimami River and ascended it and Little Swan River to a marsh in the bottom of a valley. Making his way through this marsh he came on Swan River which he descended to the Mounted Police barracks at the mouth of Snake Creek, which he reached fifty-one days after leaving the mouth of Red Deer River. From here he made short excursions into the adjoining hills to the north-east and south-east. From Fort Pelly he descended the Assiniboine to Fort Ellice, whence he returned east.

The year was one of very high water, and much of the country immediately adjoining the lakes was flooded. He mentions the occurrence of limestone on lakes Manitoba and Winnipegosis, and especially notices the great fertility of the soil.

The salt springs are discussed at some length and a list is given of a number of places where they are to be found. On Red Deer River he records the occurrence of outcrops of fossiliferous limestone below Red Deer Lake and sandstone above it. The consideration of the extent and character of the forests in this valley is not the least interesting part of his report.‡

T. Guerin, 1881.

In the same summer, Thomas Guerin, C.E., was sent by the Department of Public Works to find out the cause of the abnormal rise of

*Report on an Exploratory Survey between Lake Winnipegosis and Livingstone during the summer and autumn of 1874 by Granville C. Cunningham. Appendix L. C. P. R., Rep., 1877, pp. 185-188. Ottawa, 1877.

†Boring made on Swan River, near Fort Pelly, in 1875. Alfred R. C. Selwyn. Geol. Survey of Canada, Rept. of Prog., 1875-76, pp. 292-3. Montreal, 1877.

‡Report on Exploration by Prof. John Macoun, M.A., F.L.S. Ann. Rep., Dept. of Interior, 1881, Pt. I., pp. 67-88. Ottawa, 1882.

the water in Manitoba and St. Martin's lakes during that and the preceding year, and if possible to devise some means of lowering the water and keeping it at its normal level. He found that a band of limestone stretched across the head of the Fairford River. The White Mud, Waterhen, Fairford and St. Martin's (Little Saskatchewan) rivers were measured and cross sections were made, and the total amount of water discharged by each of them at that time was calculated.*

Several surveys have been made by the Dominion Lands Branch of D. L. surveys. the Department of Interior, among which the most important are the following :

In the winter of 1878, Wm. Wagner made a transit and chain traverse of Lake Manitoba. /

In the winter of 1880, Wm. Pearce, D.L.S., ran the meridian township outline between ranges 18 and 19 in the old system of survey on the ice across Winnipegosis and Cedar lakes.

In the summer of 1887, J. I. Dufresne, D.L.S., made a survey with transit and micrometer of the south and west shores of Lake Winnipegosis, and of Shoal River and Swan Lake. In his report he gives generally the character of any timber seen, and the positions of a number of outcrops of limestone.†

As a result of the present exploration, the following reports and papers have already been published : Previous reports on the work of this exploration.

Harrington, B. J.—On the so-called Amber of Cedar Lake, North Saskatchewan, Canada. Am. Jour. Sci., Vol. 42 (Oct., 1891), pp. 332–5.

Jones, Prof. T. Rupert.—On some Ostracoda from the Cambro-Silurian, Silurian and Devonian rocks. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part III., with 3 plates. Montreal, 1891.

Nicholson, H. Alleyne.—On some new or imperfectly known species of Stromatoporoids. Ann. & Mag. N. Hist., ser. 6, Vol. VII. (Apl., 1891,) pp. 309–328, with 2 plates.

Dawson, Sir William, and Prof. D. P. Penhallow.—On the Pleistocene Flora of Canada. Bull. Geol. Soc. Am., Vol. I. (1890) pp. 311–334.

Rüst, Dr. D.—Radiolaria from the Pierre Formation of Northwestern Manitoba. Geol. Sur. Can., Contribs. to Can. Micro-Pal., Part IV., with 3 plates. Ottawa, 1892.

*General Report of the Minister of Public Works from 30th June, 1867, to 1st July, 1882, pp. 535–536. Ottawa, 1883.

†Exploratory Survey of Lake Winnipegosis and of Swan and Red Deer (Overflowing) Rivers. Ann. Rep. Dept. Interior, 1887, Pt. II., pp. 71–74. Ottawa, 1888.

Penhallow, D. P.—A new species of *Larix* from the Interglacial of Manitoba. Am. Geol., Vol. 9 (June, 1892) pp. 368–371.

Scudder, S. H.—Canadian Fossil Insects. Geol. Sur. Can., Contribs. to Can. Pal., Vol. II., pp. 30–31, with plate. Ottawa, 1892.

Whiteaves, J. F.—On some Cretaceous fossils from British Columbia, the North-west Territory and Manitoba. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part II., pp. 185–196, with plate. Montreal, 1889.

Whiteaves, J. F.—Descriptions of some new or previously unrecorded species of fossils from the Devonian rocks of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., Sec. IV., pp. 93–110, with 7 plates. Montreal, 1891.

Whiteaves, J. F.—Descriptions of four new species of fossils from the Silurian rocks of the south-eastern portion of the District of Saskatchewan. Can. Rec. Sci., Vol. IV., Apl., 1891, pp. 293–303, with plate.

Whiteaves, J. F.—The Fossils of the Devonian rocks of the islands, shores or immediate vicinity of Lakes Manitoba and Winnipegosis. Geol. Sur. Can., Contribs. to Can. Pal., Vol. I., Part IV., with 15 plates. Ottawa, 1892.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. IV., 1888–9. Part R., 1890, p. 6 R.

Hoffmann, G. Christian.—Chemical Contributions to the Geology of Canada. Geol. Sur. Can., Ann. Rep., N.S., Vol. V., 1889–90–91. Part R., 1892, pp. 26–37.

Tyrrell, J. B.—Short account of the work done in the Duck and Riding Mountains in 1887. Ann. Rep., Dept. of Int., 1887. Part III., pp. 11–14. Ottawa, 1888.

Tyrrell, J. B.—Short account of the examinations of Lakes Manitoba and St. Martin. Ann. Rep., Dept. of Int., 1888. Part III., pp. 12–14. Ottawa, 1889.

Tyrrell, J. B.—Short account of the examinations of Lake Winnipegosis and vicinity. Ann. Rep., Dept. of Int., 1889. Part III., pp. 12–18. Ottawa, 1890.

Tyrrell, J. B.—Short account of the Assiniboine and Lower Saskatchewan Rivers. Sum. Rep.; Geol. Sur. Dept., 1890, pp. 19–26. Ottawa, 1891.

Tyrrell, J. B.—Notes to accompany a preliminary map of Duck and Riding Mountains in North-western Manitoba. Geol. Sur. Can., Ann. Rep. N.S., Vol. III., 1887–8. Pt. E. Montreal, 1888.

Tyrrell, J. B.—Gypsum Deposits in Northern Manitoba. Can. Rec. Sci. (Apl., 1889), Vol. III., pp. 353–360.

Tyrrell, J. B.—Post-Tertiary Deposits of Manitoba and the adjoining Territories of North-western Canada. Bull. Geol. Soc. Am., Vol. I., Apl., 1890, pp. 395–410.

Tyrrell, J. B.—Foraminifera and Radiolaria from the Cretaceous of Manitoba. Trans. Roy. Soc. Can., Vol. VIII., 1890, Sec. IV., pp. 111–115.

Tyrrell, J. B.—The Cretaceous of Manitoba. Am. Jour. Sci., Vol. XL., 3rd Ser., Sept., 1890, pp. 227–232.

Tyrrell, J. B.—Pleistocene of the Winnipeg Basin. Am. Geol., Vol. VII., July, 1891, pp. 19–28.

Tyrrell, J. B.—Three deep Wells in Manitoba Trans. Roy. Soc Can., Vol. IX., 1891, Sec. IV., pp. 91–104.

PHYSICAL GEOGRAPHY.

GENERAL FEATURES.

Position and area.

The map accompanying this report covers an area lying between latitudes $50^{\circ} 47'$ and $53^{\circ} 19' 30''$ north, and longitudes $98^{\circ} 40'$ and $101^{\circ} 56' 30''$ west, measured along its southern margin, and thus incloses about 25,300 square miles. Of this area 15,600 square miles are within the province of Manitoba; 5,600 square miles are in the district of Saskatchewan, and 1,500 are within the district of Assiniboria. About 4,000 square miles in the north-eastern and north-western portions of this region are as yet unexplored, so that the total area mapped and described in the following report slightly exceeds 21,000 square miles. At the commencement of the exploration it was intended to confine the work to the country lying south of the Saskatchewan River, and the main portion of the report is written with this impression in view; but on account of the uncertainty in which the exact taxonomic position of the rocks on the east side of Lake Winnipegosis was then left it was found necessary to extend the exploration to Cedar Lake and the lower stretches of the Saskatchewan, east of that lake, and a brief description of the geology of this water-stretch which has been so often travelled, but was yet so imperfectly known, has been incorporated.

Lacustral plain.

The general character of the surface is remarkably simple and is well shown by the contour lines on the accompanying map. The eastern two-thirds of the district is a lightly undulating plain sloping gently to the bottom of Lake Winnipeg. The depressions in the surface of this great plain are filled with shallow bodies of water with more or less irregular confines, and their waters are more or less rily from the presence of suspended clayey matter degraded by the waves from the surrounding shores of boulder clay or alluvium. These lakes are connected by short rapid streams, generally navigable for canoes, and with the exception of Swan and Red Deer lakes are chiefly fed by streams running from the face of the Manitoba escarpment.

Manitoba escarpment.

This escarpment is the most prominent geographical feature of the whole region. It rises from the lacustral plain, at first by a very gentle incline which gradually becomes steeper, till in the more typical places it reaches an almost abrupt declivity of several hundred feet. From the top of this escarpment, if a favourable place be chosen, not too much obstructed by forest growth, a far-reaching view may be had of

the vast plain stretching apparently from beneath the feet of the observer to the almost level horizon.

West of the brow of the escarpment lies the rugged table land of Table land, the Riding, Duck and Porcupine Mountains, often still rising for several hundred feet to extreme heights of more than two thousand seven hundred feet above the sea, or two thousand feet above the surface of Lake Winnipeg, and then declining gradually towards the south-west. This table land is generally densely wooded and travel over it is necessarily slow and difficult, but wherever examined, its summit near the edge of the escarpment was found to consist of irregular boulder-covered hills, wooded with small pine and spruce, while farther west extensive level tracts were found clothed with large spruce, and still further west it is trenched by deep valleys carrying small tributary streams down to the Assiniboine River.

Both to the south and north of Porcupine Mountain the table land Valleys. is cut through by large and very ancient valleys at present drained by Swan and Red Deer rivers, valleys that have evidently been formed by streams that flowed eastward into the great river that ran between the face of the escarpment and the Archæan plain east of Lake Winnipeg.

In the south-westerly part of the district the slope is towards the valley of the Assiniboine, and the country gradually changes from a thick forest, through partly wooded country, to open prairie. .

The drainage of the whole surface finds its way into Lake Winnipeg, and thence by the Nelson River to Hudson Bay ; but it discharges into Lake Winnipeg by three distinct and widely separated channels, viz., the Saskatchewan, the St. Martin's or Little Saskatchewan, and the Red rivers.

Across the north-east corner of this district the Saskatchewan carries the snow-waters of the Rocky Mountains to Lake Winnipeg, but no tributaries of any size join it here.

St. Martin's River empties into Sturgeon Bay on the south-west side of Lake Winnipeg, one hundred miles south-east of the mouth of the Saskatchewan, and carries with it the drainage of the greater part of this area. It is the channel of overflow of lakes St. Martin and Manitoba, and the chief tributary of this latter lake is the Waterhen River flowing from Waterhen Lake and Lake Winnipegos. This lake is the collecting basin for the water draining the eastern face of the Manitoba escarpment, and those portions of the plains tributary to the Swan and Red Deer rivers.

The south-western corner of the district is drained by the Assini- Assiniboine River. boine which enters it from the west at Fort Pelly. It immediately

turns sharply to the S.S.E., and flowing for nearly eighty miles, leaves it just east of the western boundary of Manitoba. In this distance it receives the White Sand and other tributaries from the west, and the Little Boggy, Big Boggy and Shell rivers from the east, carrying off the drainage of the greater portion of the summit plateau of the Duck Mountain.

Adaptabilities of the country. The adaptabilities of the country are very varied, and will be discussed at greater length in succeeding pages of the report, when the different areas are considered in detail ; but it may be stated that the slope extending from the foot of the more abrupt escarpment to the western shores of Lakes Manitoba and Winnipegosis and the valleys of Swan and Red Deer rivers is eminently fitted for mixed farming. It is well supplied with water, though much of it needs to be drained. It is also for the most part underlaid by a clay soil derived from the degradation of the soft limestones and shales of the Cretaceous beds to the west, and is greatly enriched by the abundance of phosphatic material supplied by large deposits of fish remains included in these beds. In the immediate vicinity of the large lakes and on their eastern side the amount of alluvium is comparatively very small, but doubtless much of the calcareous boulder-clay with which the country is covered would be found to yield profitable harvests of the more hardy roots and cereals.

The country west of the escarpment in this part of Manitoba will probably never be a very successful wheat-raising district, but the harder cereals can be grown with the assurance of an abundant crop, and the country is eminently suited to the raising of cattle for dairy-ing purposes, for rich nutritious grass covers the surface everywhere except in the dense forest.

Natural products.

Much fine timber is growing on the remoter parts of the mountains, but a very large amount of spruce has during late years been destroyed by forest fires.

The manufacture of salt could readily be carried on, especially in the vicinity of Dawson Bay, where the natural brine springs are much more copious than elsewhere.

The lakes abound in food-fish, and with careful fishing can be made to yield a large and constant supply. Much large game is still to be found. Moose are plentiful throughout the wooded tracts everywhere ; caribou are especially numerous on the east side of Lake Winnipegosis, and a few elk are still to be found between Riding Mountain and lakes Manitoba and Winnipegosis. The black bear wanders along the streams and by the lakes. Other fur-bearing

animals common to Manitoba and the North-west are taken by the hunters in greater or less abundance.

The climate is remarkably clear and beautiful. In June and July, Climate. the prevalent winds are from the south, ushering in warm days accompanied by frequent heavy showers of rain, while later in the year westerly and north-westerly winds prevail accompanied by drier weather.

Frost generally occurs in the early part of June and the latter part Frost. of August on the high lands west of the Manitoba escarpment, but the country to the east of this line enjoys a greater interval between the frost periods.

The following table has been kindly prepared by Prof. C. Carpmael, Director of the Canadian Meteorological Service, and shows the temperature and rainfall better and clearer than any extended discussion would do. It is prepared for Minnedosa which is situated in a wide valley on the edge of the escarpment, on the eastern side of range 18, and thirty-five miles south of the limit of the accompanying map, and Russell at the terminus of the Manitoba and North-western Railway. The observing station at Minnedosa has an elevation of 1,689 feet above the sea, and that at Russell an elevation of about 1,830 feet. This latter is the only place in the district at which meteorological observations are at present taken, but the record is doubtless essentially correct for the country north at least to the Swan River valley, while the daily range in summer on the lacustral plain is certainly less than on the higher table land, and there is thus less probability of erratic frost.

STATISTICS of Temperature and Precipitation at Minnedosa, Manitoba, Latitude North $51^{\circ} 10'$, Longitude West, $99^{\circ} 48'$, height above sea, 1,665 feet.

By PROF. C. CARPMAEL,

AVERAGE MONTHLY TEMPERATURE.

Year.	England.												Total.
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	
1881	6.67	8.63	28.62	47.55	65.25	61.35	47.24	30.22	12.26	9.78	2.80	32.06	30.52
1882	7.01	5.86	30.96	44.40	57.71	58.19	57.85	53.66	38.19	18.29	-0.42	28.32	30.52
1883	15.38	10.76	10.52	31.97	50.83	62.07	56.81	58.05	46.52	36.34	-4.80	29.01	30.52
1884	7.63	6.87	11.77	34.09	46.70	55.68	60.48	54.08	49.02	34.97	24.94	10.16	30.24
1885	14.43	1.23	13.75	38.98	52.09	60.70	66.76	59.50	44.70	41.07	16.12	-1.15	31.61
1886	13.45	7.96	11.75	34.16	53.13	60.98	62.17	56.61	50.55	31.13	17.12	0.31	29.71
1887	11.55	1.18	3.94	28.98	44.28	58.97	62.37	55.89	47.08	35.08	18.30	12.28	29.54
1888	4.92	4.06	24.82	40.47	48.76	62.50	63.36	62.18	45.75	35.08	19.78	7.59	34.26
1889	11.52	8.64	7.70	35.82	42.10	65.18	65.36	57.41	45.06	38.26	..	..	..
Average	-9.31	-2.73	10.97	33.78	47.77	60.11	62.17	58.76	47.75	35.39	17.47	4.06	30.52

AVERAGE MONTHLY MAXIMUM.

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

1881	-12.3	-4.7	-2.4	18.7	35.2	45.2	53.6	51.1	37.6	21.7	4.2	0.4
1882	-16.0	-7.7	21.1	30.1	44.1	45.1	49.5	52.9	41.0	29.2	10.5	-7.7
1883	-26.6	-21.5	-1.2	21.0	34.8	49.5	44.0	45.6	35.2	24.6	0.1	-12.5
1884	-25.0	-20.6	-1.3	22.1	33.2	41.6	48.2	41.3	36.0	25.4	6.2	-20.0
1885	-25.2	-13.6	-0.2	26.5	35.7	44.0	51.1	44.3	33.8	23.7	16.4	-5.1
1886	-26.9	-21.3	-2.0	20.9	39.1	47.4	47.8	42.5	31.2	28.8	3.2	-13.2
1887	-13.5	-8.8	18.5	28.7	45.5	49.0	42.2	36.2	36.5	18.5	5.0	-10.2
1888	-23.7	-15.2	15.3	28.3	34.4	44.8	48.9	46.9	35.9	28.8	11.1	3.4
1889	-6.0	-18.7	-3.9	24.9	29.1	50.5	50.9	43.6	34.7	26.0	10.5	-3.7
1890	-20.7	-16.3	-1.4	22.6	33.4	45.8	48.7	45.5	35.8	25.9	7.5	-7.6
Average	-21.4	-16.3	-1.4	22.6	33.4	45.8	48.7	45.5	35.8	25.9	7.5	-7.6
Mean Daily Range	23.1	23.8	25.1	22.9	28.4	26.1	26.4	27.1	26.7	21.1	20.2	22.1

HIGHEST TEMPERATURE REGISTERED.

1881	35.8	27.4	40.8	76.0	78.0	82.8	86.5	86.6	85.6	74.5	59.7	45.6
1882	28.1	38.5	42.8	48.6	78.7	81.8	84.8	82.0	63.7	41.0	31.7	36.4
1883	28.5	37.9	36.6	68.0	72.3	91.8	81.8	78.8	77.8	56.2	44.8	36.3
1884	19.9	28.7	43.8	64.2	82.0	88.0	77.3	85.0	69.6	72.8	49.7	41.6
1885	27.5	41.8	40.2	63.3	76.8	83.3	88.2	82.0	82.3	82.8	44.8	38.9
1886	19.9	44.6	47.6	76.3	83.8	88.0	92.0	102.6	92.6	82.4	63.2	38.8
1887	21.7	21.7	47.6	79.8	90.0	86.3	89.8	82.8	83.8	67.2	66.5	33.6
1888	35.9	38.4	36.9	66.1	73.2	93.8	84.3	84.3	75.8	47.3	37.9	93.8
1889	35.4	39.8	66.2	79.8	81.3	98.8	88.8	92.7	93.3	81.1	57.7	34.9
1890	28.4	35.4	35.7	69.8	68.8	87.3	94.3	90.4	87.1	82.8	56.2	34.9
Average	28.1	35.4	43.8	69.2	78.5	88.2	86.8	87.1	81.6	71.2	51.7	36.6

STATISTICS OF TEMPERATURE AND PRECIPITATION AT MINNEDOSA, MANITOBA, &c.—Continued.

LOWEST TEMPERATURE REGISTERED.

RAINFALL IN INCHES.

SNOW, IN INCHES, AND TOTAL PRECIPITATION.

	1·5	27·0	8·0	8·0	0	0	0	0	10·0	14·6	2·0	71·1
1881	14·5	9·0	12·0	4·5	*	0	0	0	4·0	14·1	6·0	64·1
1882	4·0	5·7	8·5	11·5	*	0	0	0	*	4·5	18·5	52·7
1883	6·8	5·7	10·0	9·9	0	0	0	0	6·2	7·6	6·2	52·4
1884	2·8	5·4	9·6	8·8	1·5	0	0	0	5·0	1·3	10·8	45·2
1885	5·1	5·0	4·0	9·4	*	0	0	0	0·5	1·1	4·1	30·6
1886	4·9	5·0	2·1	8·3	1·0	0·5	0	0	0	1·3	1·4	39·8
1887	4·8	2·5	10·0	10·1	0·7	0	0	0	0	8·4	4·0	45·0
1888	10·4	5·1	0·9	1·7	*	0	0	0	*	0·6	4·9	12·3
1889	3·3	23·0	2·3	1·4	3·3	0	0	0	*	2·2	.....	35·9
Average	5·8	9·3	6·7	7·4	0·7	*	.....	.....	*	3·9	7·1	7·8
Total rain and melted snow	0·58	0·93	0·68	1·31	1·75	3·62	2·57	1·90	1·43	1·65	0·77	48·7

NUMBER OF DAYS OF RAIN.

	0	0	0	5	15	16	11	14	18	2	4	1	0
1881	0	0	0	3	10	10	9	6	12	3	9	1	0
1882	0	0	0	1	6	15	13	7	17	4	10	0	0
1883	0	0	0	4	2	9	17	12	15	5	3	1	0
1884	0	0	0	8	10	9	18	15	12	11	9	0	0
1885	0	1	0	7	13	15	12	12	11	9	6	0	0
1886	0	0	0	4	12	15	13	12	10	11	3	2	0
1887	0	0	0	3	8	12	15	15	10	9	0	0	0
1888	0	0	0	6	13	9	5	4	9	3	1	0	0
1889	0	0	4	6	14	14	13	14	12	16	0	0	0
1890	0	0	0	5	5	10	12	13	10	10	10	7	1
Average	0	R.	R.	5	10	12	13	10	10	7	1	R.	68

NUMBER OF DAYS OF SNOW.

	4	16	6	5	0	0	0	0	0	5	2	11	5
1881	9	3	5	1	0	0	0	0	0	2	9	12	40
1882	4	3	3	1	0	0	0	0	1	5	7	7	39
1883	10	9	7	9	0	0	0	0	0	7	7	7	10
1884	8	7	13	8	4	0	0	0	0	6	5	5	59
1885	13	12	14	2	2	1	0	0	1	1	1	1	13
1886	10	12	9	5	3	0	0	0	0	0	0	8	64
1887	10	9	12	7	2	0	0	0	0	0	0	0	55
1888	13	7	5	5	0	0	0	0	0	0	0	0	68
1889	13	7	5	2	1	0	0	0	0	0	0	0	61
1890	8	12	3	5	0	0	0	0	0	1	2	7	45
Average	9	9	5	2	*	0	0	0	*	4	9	0	0

Statistics of Temperature and Precipitation at Russell, Manitoba, Latitude North $50^{\circ} 42'$, Longitude West $101^{\circ} 20'$,
height above sea 1,830 feet.

BY PROF. C. CARPMAEL.

AVVERAGE MONTHLY TEMPERATURE.

Year.	AVVERAGE MONTHLY TEMPERATURE.											AVVERAGE MONTHLY MAXIMUM.			
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.		
1883	-9.35	-10.74	9.40	32.22	53.35	62.07	58.33	59.34	48.00	32.60	11.90	-2.80	28.65	...	...
1884	-13.67	-7.70	13.01	34.66	48.32	57.06	61.07	55.08	46.20	35.87	16.38	-9.24	30.24	...	...
1885	-18.16	0.94	11.99	38.80	51.74	60.06	66.93	59.70	48.54	33.69	24.54	8.33	28.83	...	...
1886	-15.82	-11.71	11.42	34.56	52.51	59.80	62.17	57.03	49.98	31.41	16.35	-4.38	30.63	...	...
1887	-14.46	-4.77	1.89	28.51	45.01	58.89	62.07	55.44	50.36	36.99	17.50	16.72	29.51	...	...
1888	-14.87	-2.67	24.86	41.48	48.04	59.82	60.57	63.20	46.29	36.32	19.87	4.17	33.90	...	...
1889	-14.94	-11.33	6.07	33.86	40.70	62.77	61.18	55.74	46.80	38.47	...	...	...	...	...
Average	-11.65	-6.85	11.23	34.87	48.52	60.09	61.76	58.00	47.63	35.70	17.33	1.50	29.84	...	...
1883	1.7	-1.5	20.4	41.4	67.2	73.8	68.7	72.4	63.5	40.8	21.5	6.4	...	...	...
1884	4.9	2.4	21.1	44.3	60.5	69.2	71.4	67.9	56.9	46.7	24.1	0.0	...	...	...
1885	9.1	13.0	23.6	50.2	64.9	72.8	80.3	74.7	64.6	46.5	32.2	18.5	...	...	...
1886	4.4	0.8	22.2	46.3	66.3	70.9	74.0	70.8	59.6	53.6	27.8	5.2	...	...	...
1887	4.9	8.0	12.6	37.5	57.9	70.3	72.6	71.0	64.8	44.4	28.6	7.9	...	...	...
1888	11.4	1.2	36.6	54.7	62.0	75.4	75.5	79.2	61.4	45.9	27.4	21.2	...	...	...
1889	5.1	15.5	44.5	52.3	75.7	75.4	68.4	60.8	51.6	31.8	15.5	...	...	...	...
Average	5.0	21.7	45.6	61.6	72.6	74.0	72.1	62.0	47.2	27.6	10.7	...	...	...	...

AVERAGE MONTHLY MINIMUM AND MEAN DAILY RANGE.

HIGHEST TEMPERATURE REGISTERED.

LOWEST TEMPERATURE REGISTERED.

NORTH-WESTERN MANITOBA.

STATISTICS OF TEMPERATURE AND PRECIPITATION AT RUSSELL, MANITOBA.—*Continued.*

RAINFALL IN INCHES.

SNOW IN INCHES AND TOTAL PRECIPITATION.

NUMBER OF DAYS OF RAIN.

	0	0	1	0	9	15	13	9	4	11	5	1	0	0
1883	0	0	0	5	2	14	17	12	18	7	3	0	0	62
1884	0	0	1	0	10	13	16	14	17	9	5	1	0	74
1885	0	0	1	6	8	7	9	9	9	7	2	0	0	70
1886	0	1	0	5	4	15	14	11	10	7	2	0	0	56
1887	0	0	0	0	7	7	11	9	6	11	3	0	0	65
1888	0	0	0	2	2	9	7	13	5	8	4	1	0	49
1889	0	1	2	7	13	14	14	12	11	8	...	...	0	57
1890	0	0	0	7	13	14	14	12	11	8	...	...	0	79
Average	0	0	1	4	9	12	13	10	9	5	1	R	1	64

NUMBER OF DAYS OF SNOW.

	0	0	3	0	0	0	0	0	0	1	10	9	9	...
1883	14	10	10	3	0	0	0	0	0	5	9	9	9	60
1884	7	9	14	8	2	0	0	0	0	9	6	13	13	68
1885	14	9	15	3	4	0	0	0	0	3	7	6	13	61
1886	11	12	9	5	1	0	0	0	0	10	10	14	14	72
1887	8	8	12	5	2	0	0	0	0	3	5	7	7	50
1888	10	4	2	2	1	0	0	0	0	2	7	9	9	38
1889	6	8	8	4	9	0	0	0	0	5	...	...	...	...
1890	10	9	10	4	3	0	0	0	0	*	5	8	10	59
Average	10	9	10	4	3	0	0	0	0	*	5	8	10	59

THE LACustral PLAIN.

This plain presents a slightly undulating surface which extends from the foot of the Manitoba escarpment to the east shore of Lake Winnipeg. It is thinly covered with alluvial or glacial deposits, through which the underlying limestones occasionally project and form islands or cliffs on the lakes, or more or less conspicuous hills inland. The depressions in the surface of this plain are filled with lakes that vary much in size and contour. The following are the most important of these embraced within the scope of this report :—

Manitoba, Ebb and Flow, Partridge Crop, Winnipegosis, Waterhen, Swan, Pelican, Red Deer, Cedar and Cross Lakes, together with a number of small lakes in the totally unexplored region east of Lake Winnipegosis. The plain can be best described in connection with the larger bodies of water on its surface.

LAKE MANITOBA.

Position.

Lake Manitoba lies between latitudes $50^{\circ} 11'$ and $51^{\circ} 48'$ north, and longitudes $97^{\circ} 56'$ and $99^{\circ} 35'$ west, extending in a general direction N. 25° W.

Altitude.

Its mean altitude above the sea is 810 feet, as shown by the profiles of the original location of the Canadian Pacific Railway. This railway survey line was run in the winter of 1874–75, and the difference between high and low water at Sifton Narrows, where the line crossed the lake, is given in the profile at two feet. The high water in Lake Manitoba is given by the same profile as ninety-nine feet above the level of the ice crossing of Red River, near the village of West Selkirk, or eighty-eight feet above the level of the water mark of the freshet of 1852. This latter point is given by J. H. Rowan, C.E.,* one of the engineers of the old location, at 16·55 feet above the mean level of the water in Lake Winnipeg. The height of Lake Winnipeg is 710 feet above the sea, and therefore the high water at the Narrows of Lake Manitoba as determined in the winter of 1874–75 is 104·55 feet above Lake Winnipeg or 814·55 feet above the sea. The low water is put at only two feet below high water, which is much less than it should be, since in 1881, Mr. Guerint† found the lake to be six feet above its normal low water level. As 1874 and 1875 were years of rather high water, four and a half feet may be taken from the high water mark then observed, thus giving 810

* The Red River, by James H. Rowan. Transaction 13, Man. Hist. & Sci. Soc., Winnipeg, 1874.

† Public Works Report, 1867–1882.

feet as the mean height of the lake as stated above. This agrees closely with the height given by Mr. Upham* for the mean altitude of the same lake.

The lake has a total length of 119 miles, and is divided into two parts by a strait known as "The Narrows" which, to distinguish it from other places with the same local appellation, might be known as "Sifton Narrows," from Mr. Sifton who has kept a trading store at this place for some years. The channel here contracts to a width of 2,650 feet with a maximum depth of fifteen feet. This strait divides the lake into two distinct portions differing widely in their physical features. The southern portion is sixty-three miles long, and twenty-nine miles wide in its widest part, and has generally a moderately even regular contour, with very few islands, except immediately south of Sifton Narrows. The shore line of this portion amounts to 160 miles and its total area to 1,039 square miles.

Southern portion.

The lake north of the Narrows is very different from that to the south. It is cut by long stony points into deep bays, and while the total length is only fifty-six miles, the length of shore line is 375 miles, and the total area is only 672 square miles. The greatest depth found in this northern portion is twenty-one feet six inches, and the average depth of the middle of the lake east of Crane River Narrows is about sixteen feet. The southern expansion of the lake is reported to have about the same general depth. The mean depth of the lake may therefore be assumed at twelve feet, and as its total area is 1,711 square miles, its total capacity is about 572,399,308,800 cubic feet.

The only considerable streams flowing into the lake are White Mud River at its south end, and Waterhen River at its north end. These were measured by Thomas Guerin in the summer of 1881, and were found to be then discharging respectively 1,425 and 13,930 cubic feet of water per second, while at the same time the Fairford River was discharging from the lake 14,833 cubic feet per second. This would leave a surplus in the lake, to be removed by evaporation, of 522 cubic feet a second or 45,100,800 cubic feet a day, and other small tributaries would probably bring this surplus up to 60,000,000 cubic feet a day, or only .01 of an inch over the whole surface of the lake. By consulting the table of rainfall given above, it will be seen that the mean rainfall for the three months of June, July and August is 8.09 inches, or .088 inches a day, and this added to the .01 inch obtained above would give .098 inch a day as the mean daily evaporation from the

Rise and fall
of water.

* Report of Exploration of the Glacial Lake Agassiz in Manitoba by Warren Upham. Geol. Surv. of Can. Ann. Rept., Vol. IV., p. 155 E.

surface of this lake. It is not improbable, however, that the surplus water left in the lake is greater than that given above, and Mr. Guerin's experiments at Fairford on evaporation would appear to indicate that this was the case, as for the month of August, 1881, he found that the amount of water evaporated from a shallow vessel was about $5\frac{1}{4}$ inches. In that year also the channels of the above named three rivers were filled well up to their brims, while in 1888 and 1889 the water was low and there was a drop of several feet from the brink of the channel to the surface of the stream.

Periods of high and low water.

Periods of high and low water occur at apparently long and irregular intervals, and are caused by excessive rainfall and excessive drought. In general, however, the lakes may be said to oscillate about a foot above or below the normal. In 1880 the lake was very high, whereas in 1889 it was very low. In 1858 Professor Hind* states that the water was two feet above its lowest level, that in 1852 there was a period of very high water, previous to which for a long time the water had been very low. In 1826 there was another period of high water, anterior to which there would appear to be as yet no very definite published record.

Wind.

The winds have a very marked effect on the height of the water at any particular place on the shore of this, or of the adjoining shallow lakes. With a wind blowing from the north-west or south-east, the water is driven towards the opposite end of the lake, and the lake being so shallow, the undertow is not able to form a continuous current beneath the surface. The water, blown forward by the wind, can return only by a series of interrupted undercurrents which are incapable of preventing it from being piled up at the extremity of the lake towards which the wind is blowing.

Temperature

On account of the shallowness of the water, its temperature is comparatively high during the summer months, and this large body of warm water exerts a very great influence in reducing the daily range of temperature and thus preventing summer frosts.

On page 47, will be found a list of observations on the temperature of the water of Lake Winnipegosis during the summer and autumn of 1889, and it is probable that the temperature of Lake Manitoba will average slightly higher.

Record of the freezing and thawing of the lake.

The lake annually freezes over, but no exact records have up to the present been systematically kept of the date in the autumn when it first becomes covered with ice, or of the date in the spring when the ice breaks up and again opens the lake for navigation.

* Report on the Assiniboine and Saskatchewan Exploring Expedition. 4to. Toronto, 1859, p. 102.

The following extracts have been taken from the "Journal of Occurrences" kept at the Hudson's Bay Company's Post of Manitoba House, on the west side of the lake, and are published with the permission of Mr. Joseph Wrigley, Commissioner of the Company:

Record of the
freezing and
thawing of the
lake.

- Oct. 23, 1881. Ice all disappeared.
- Nov. 3, 1881. Lake frozen about the shores.
- " 10, 1881. Lake frozen fast as far as the eye can see.
- May 13, 1882. The lake is now open in places along the shore.
- " 16, 1882. Ice moved a little north.
- " 17, 1882. Ice breaking up rapidly.
- " 18, 1882. Ice drifting north, large spaces of open water to be seen in every direction.
- May 20, 1882. No ice to be seen as far as the eye can reach, so that it may be said *the lake is now open*.
- May 22, 1882. Small boat passed en route to Totogen.
- " 17, 1883. Ice seems to be much broken up, and open water is to be seen in many places.
- May 18, 1883. The wind veering to the north in the afternoon, the ice began to break up and drift to the south, so that at 6 p.m. the bay was clear.
- May 19, 1883. No ice is to be seen, so that navigation is open.
- Nov. 1, 1883. Ice forming rapidly along the shores.
- " 5, 1883. Boat passed to Totogen.
- " 6, 1883. Froze hard last night, so that the lake opposite is nearly all frozen over. Outer lake, except bays, still open.
- Nov. 7, 1883. Outer lake open.
- " 9, 1883. Beyond the village the lake is still open.
- " 10, 1883. The lake is to-day, as far as the eye can reach, all fast with ice.
- May 12, 1884. Ice moved a few yards southward to-day.
- " 16, 1884. Spaces of open water to be seen on east shore.
- " 17, 1884. N.-E. wind cleared the bay of ice.
- " 19, 1884. No ice to be seen.
- Oct. 27, 1884. All the lake closed in with ice as far as the eye can see.
- May 13, 1885. Open patches of water to be seen.
- " 16, 1885. Ice moving about.
- " 18, 1885. Lake clear of ice.
- Nov. 1, 1885. Ice to be seen on the bay this morning, a thin skim covering the whole bay.
- Nov. 2, 1885. The whole lake, as far as can be seen, frozen over.
- " 7, 1885. The lake found to be still open on the other side.

Record of the
freezing and
thawing of the
lake—*Con.*

April 30, 1886. Open water to be seen right across to Sugar Island.

May 6, 1886. Schooner passed to Totogen.

Nov. 5, 1886. Thin skim of ice over portions of the bay.

" 16, 1886. Lake all frozen over.

May 7, 1887. Ice moved a little.

" 14, 1887. The lake clear of ice.

The following information was obtained from Mr. McKay, J.P., who has lived by Lake Manitoba for many years.

For the opening of the lake :

In 1889. April 18th, the earliest known.

In 1866. May 20th, the latest known.

The average would be from the 10th to the 15th of May.

The lake frozen over :

In 1883. October 18th, the earliest date known in thirty years.

In 1874. November 13th, the latest date known in thirty years.

In 1871. Commenced to freeze on October 24th, but was not frozen over till November 2nd.

The average date of the closing of York boat navigation is about October 28th.

The water in the lake throughout the summer is slightly milky, from the presence of fine clayey material in suspension, which is stirred up by storms from the low shores and the soft, shallow bottom.

Shores and Islands.

Southern
expansion of
lake.

The southern expansion of the lake lies almost entirely beyond the limit of the accompanying map, but its western side was examined when proceeding from Westbourne, where the expedition started in 1888, and was found to be composed very largely of a low sand or gravel beach behind a soft clay shore studded with boulders. Behind the beach is a level country, often marshy, extending back to a forest of poplar or spruce. At Manitoba House the shore is higher, sloping up to a gravel ridge in a narrow belt of timber.

Manitoba
House.

The Hudson's Bay Company's trading post of Manitoba House is beautifully situated on this slope, and looks out over a narrow streak of water towards some islands thickly wooded with poplar and maple, to which the Indians annually resort in the spring to boil down the sap of the latter tree for sugar.

Mr. David Armitt, who was in charge of the trading post in 1889, informed me that the present house was built by Ewan Macdonald in 1870, and that the house which was being built by Mr. McKenzie in 1858, when the place was visited by Mr. H. Y. Hind, was about 300 yards further south, where the ruins can still be seen.

Between Manitoba House and Sifton Narrows, the shores, both of the islands and the mainland, are low, and usually protected by a shingle beach of irregular, waterworn limestone pebbles, behind which stretch woods of poplar, willow, and occasionally ash-leaved maple. One point, north of the creek into Ebb and Flow Lake, is composed of Archaean boulders, and other parts of the shore are low and marshy.

On the west side of Sifton Narrows, is the Indian agency, and a Sifton Narrows.
trading store kept by Mr. Sifton. A quarter of a mile south from this store, in the extreme south-west corner of section 22, township 24, range 10, west of the Principal Meridian, is the site of some old buildings which, the Indians informed me, were formerly a trading post of the Hudson's Bay Company. Nothing now remains but a small chimney-mound and three hollows in the midst of a grove of willows, between which and the edge of the lake is a grassy meadow 120 yards wide, and level to near the edge of the water, where it is bounded by a gravel ridge. To the west the land is still level, but covered with small poplar, mixed with a few small ash and elm.

North of the Indian agency the shore is at first soft, but it soon becomes skirted by a gravel bar which extends to an outcrop of compact Devonian limestone.

To the east of this rock outcrop, and at the north end of the Manitoba strait, is Manitoba Island, with an area of about 160 acres, and rising from fifteen to twenty feet above the water. Its interior is either wooded with poplar and birch, or is open and grassy, or covered with underbrush of amelanchier and choke cherry. On the shores elm is also growing to a large size. While the east and west sides of the island slope more or less gradually to the water, the north side presents an abrupt cliff of limestone twelve feet high, from the foot of which a talus of limestone gravel fifty feet wide slopes to the lake. The limestone is very compact and resonant, and when the waves beat against this beach and throw these resounding pebbles one on another, the roaring sound will undoubtedly be produced which has given rise to the superstition among the Indians that a Manito or Spirit beats a drum or otherwise makes a noise on the island. The strait past the island was therefore called Manito-wapow (*Cree*), or Manito-baw (*Ojibway*), meaning the Strait of the Spirit or Manito.

At the west end of the cliff the gravel beach runs out into deep Horseshoe Harbour, and incloses a beautiful little harbour, known as Horseshoe Harbour, where the small freighting boats can find shelter on their way up and down the lake.

Following the east side of the lake northward from Manitoba Island the shore line is indented by deep marshy bays, surrounded by low

country, either marshy or wooded with poplar and some spruce, while the points, which are also not more than a few feet above the water, Point Richard are generally guarded by a wall of Laurentian boulders. Point Richard is of this character, and off it are some small bare islands, consisting of bars of sand and small limestone gravel scattered over with large boulders of gneiss and cream-coloured limestone. To the northward lies Reed Island, wooded in the interior and apparently surrounded by a white sandy beach.

Dog-hung Bay East of Reed Island is a deep rounded bay, known as Dog-hung Bay, extending beyond the eastern confines of the map. The prominent points in this bay are all composed of boulders piled in an even slope to a height of six or eight feet above the lake, while between the points is a beach of rounded limestone gravel, on which is growing a narrow belt of poplar, elm and oak. Behind the points are often small ponds, and in rear of the whole beach is an extensive open marsh, stretching back to a forest of poplar and spruce. A belt of low land is said to extend north-eastward from this bay towards Lake St. Martin, and in years of very high water this belt is entirely overflowed.

North of Dog-hung Bay, the shore maintains precisely the same character to Elm Point, which is itself a ridge or spit of limestone gravel without boulders, projecting out into the deep water of the lake, and overhung by a number of fine elm trees. North of this point the shore is more regular, without so many boulders on the points, and for a considerable stretch the drier wooded country comes to the edge of the lake, but boulders are backed up against it in a close wall. Then limestone cliffs begin to make their appearance, and continue for a couple of miles along the shore, rising at their highest point to twenty-two feet above the water. The bottom of these cliffs is hollowed out into fantastic shapes, and on their summit is a lovely stretch of open prairie, in places overshadowed by oak trees. This is one of the most charming camping places on the lake.

Steep Rock Point.

Low Island.

Off the cliff is a small wooded island, composed of flat-lying limestone and boulder clay.

From the neighbourhood of these limestone cliffs, to the mouth of Fairford River, the shore is low, and generally bordered by a gravel ridge.

Fairford River.

Fairford or Partridge Crop River discharges Lake Manitoba through Partridge Crop Lake into Lake St. Martin, and this in its turn is discharged by St. Martin or Little Saskatchewan River into Lake Winnipeg. It has a width of 700 to 900 feet, and a channel from ten to twenty feet deep. Where it leaves the lake it flows over a bed of flat-lying limestone, on which there is usually from two to three feet of

water, but after crossing this bar its banks are composed of hard, light gray clay, with a few boulders, till it passes the Mission and reaches the shallow expansion now largely covered by the water of Partridge Crop Lake. From this lake it again flows between clay banks, but in a shallow channel, to Lake St. Martin. It has a total length of ten miles, and a total fall, in this distance, of about fifteen feet. Most of the fall occurs in two rapids, one a short distance below Partridge Crop Lake, and the other a mile and a third in length, between Fairford Mission and Lake Manitoba. These are chiefly caused by the collection in the bed of the stream of great numbers of boulders of gneiss and limestone, washed out of the contiguous banks of boulder-clay.

On its upper portion the north bank of the river is generally thickly wooded with poplar, while the south bank shows several small clearings around comfortable log houses. Here are also situated the trading post of the Hudson's Bay Company and the Church of England mission, the former, a mile and a half, and the latter two miles and a half, from Lake Manitoba. The mission was first established on the less thickly wooded gravelly banks of the river below Partridge Crop Lake, but on account of floods the situation had to be abandoned, and the church and parsonage are now beautifully situated on a rising ground from twenty to thirty feet above the river, and overlooking, towards the south, a forest of poplar, spruce, and Banksian pine. Fairford Mission.

Returning to Lake Manitoba and proceeding northward from the Davis Point mouth of Fairford River the shore as far as Davis Point is generally rather low, in some places bounded by a gravel bar, and in other places it is high enough to be wooded with poplar and birch down to the beach. In the distance tall spruce trees can occasionally be seen. The point itself is composed of thick-bedded white limestone.

West of Davis Point, the north shore of Portage Bay is cut by deep narrow bays separated by long points wooded with elm and poplar. These points run out in a direction a little east of south, on the same course as the glacial striation, and are composed chiefly of large boulders of Laurentian gneiss, mixed with a very few of palaeozoic limestone.

Paonan Peninsula, as far as it was examined, was also found to be low, and surrounded by a wall of Archaean boulders, behind which, in the more southern parts, is a marsh extending back to a poplar forest ; while in its northern half the woods generally come down to the beach. Across the north end of the peninsula is a portage road 1,700 paces in length, over which the Indians often carry their canoes. At the east end of the portage, which is opposite a small island of boulders covered with a few willows, the water is very shallow, and the first few hundred yards of the portage itself are across a sloping gravel plain, extend-

ing from the water to the poplar woods. The western end of the portage is in a grove of oaks, at the bottom of a small bay opening to the south, the shores of which are sandy and piled with boulders.

West of Paonan Peninsula a long shallow bay runs to the northward. The north end of this bay is especially shallow, with stones projecting above the water in every direction, and banks of rushes growing off the beach. The surrounding country is wooded with small poplar, while spruce and tamarack can occasionally be seen in the distance.

Garden Island.

Garden Island, which lies just off the point west of the mouth of this bay, is a ridge of gravel and boulders, inclosing, in the northern part, a grassy and reedy marsh, and in other places drier land. It is wooded all around the shore, and, in the southern part, in the interior. On its western side a sand bar runs out towards the point of the main shore. The island is said to have derived its name from the fact that Indians of the Crane River band used to grow crops of potatoes here year after year.

Crane River Narrows.

West of Garden Island Point, two long points extend southward towards the opposite shore, contracting the lake in one place to less than a mile and a half in width, and from these points extend boulder-reefs, in places piled up into little islands, on which a few willows may be growing. Thus this strait is shallow and much obstructed by boulders, so that, in low water, it is difficult to find a channel through it four feet in depth. The boulders are almost all of granite or mica-schist, while many of the pebbles on the shore are of white palaeozoic limestone.

Low shore.

Between Elm Point, the most westerly of the two points above mentioned, and the mouth of Waterhen River, the shore is all composed of sand or boulders, and, like the north shore of the lake elsewhere, without any sign of fixed rock. The boulders at and near the points are piled in steep walls six to eight feet in height, and behind these walls are often groves of large elms and maples.

From the mouth of Waterhen River southward for a few miles the shore was not closely examined, but it appeared to be low, and Twin Islands. without special interest. Off the mouth of the river lie the Twin Islands, two low islands thickly wooded with poplar and elm, with a few spruce in the interior. The islands are surrounded by a beach of gravel or boulders about seven feet high, and are connected by a bar of limestone gravel half a mile long, which rises five feet above the water and has an average width of 100 feet. At the north end of this bar is a large, cairn-like heap of boulders piled up by the ice.

South of Twin Islands another similar island, wooded with poplar and ash, lies close to the shore, and is connected with it by a very similar bar of sand and fine gravel more than half a mile long, rising in some places not more than a foot above the water, and averaging only about thirty-five feet in width.

From the end of this bar to Onion Point the shore is low and sandy Onion Point, or scattered with boulders, but at the point itself a cliff of limestone, eight feet in height at its highest point, looks out in a north-westerly direction over the lake. On the top of the rock is a little oak-surrounded prairie, similar to that at Steep Rock Point already referred to, but not quite so large or open.

The next two prominent points are composed of limestone, and the Little Sandy Point. shores of the bays are thickly wooded with poplar. At Little Sandy Point there is a pile of rounded granite boulders, and just to the eastward is a high spit of sand and small rounded limestone gravel, at which the York boats usually stop on their way up the lakes, as the water is here moderately deep up to the shore.

From Little Sandy Point to the limestone cliff at Monroe Point the shore is generally low, and more or less thickly wooded with poplar. East of Monroe Point a small brook, known as Crane River, enters Crane River. the lake from the south, but it appears to carry very little water. It is quite stagnant for about a mile from the lake, to a point where there is a small Indian village, composed of a few log houses tenanted only in winter.

The east shore of Crane Bay is generally piled with boulders, while the extreme point is a high ridge of boulders extending out into the lake, on the end of which a few elms, maples and willows have grown. A quarter of a mile to the south, this ridge divides ; the branches run back and include a marsh about a mile in length and a quarter of a mile in width. The other points south of Crane River Narrows are also composed largely of boulders, and the bays between them are shallow and marshy.

South of Crane River Narrows the shore assumes a much more even Even shore. character, since the lake here extends for twenty-five miles in the direction of the general glaciation of the country, and therefore no drumlin-ridges of boulders extend out at right angles to the shore. As a rule, the water is moderately deep to within a short distance of the land. The beach in some places runs back to a ridge of boulders, but it generally consists of a bar of limestone gravel in front of a wide, level marsh, behind which are groves of poplar. It was reported that the country to the west, and for a considerable distance inland, is made up entirely of alternating bands of marsh and poplar woods extending in

Big Sandy Point.

a north and south direction. The best known harbour on this shore is at Big Sandy Point, which is a spit of sand and limestone gravel running out into deep water, just south of some low cliffs of white limestone. The harbour is not a good one, being open to the north-east wind, but the deep water close to the gravel beach makes it a convenient place to land.

Cormorants.

Near the southern end of this portion of the lake are three islands, two of them being merely piles of boulders quite bare of vegetation, while the third and largest is low and generally marshy, but bears a few bushes, and is surrounded by bars of gravel and calcareous sand, with boulders of gneiss on the points. The most westerly of the small stony islands was visited on the 4th of August, 1888, and was found to be black with great numbers of cormorants (*Phalacrocorax dilophus*), young and old, this being their principal breeding place in the lake. North-east of these islands, and at the south-eastern extremity of this stretch of open water, the lake is again shallow and contracted, the space between the point of Paonan Peninsula and the opposite shore being largely taken up by Cherry Island. The water in the main channel to the south of this island is not more than seven feet deep, while to the north of it a depth of three feet is all that was found throughout.

Cherry Island.

Cherry Island possesses a little harbour on its north-east side where the brigades of freighting boats belonging to the Hudson's Bay Company, coming from various parts of this district, used to wait for each other before proceeding on their annual trip to York Factory. The name Paonan, now given to the peninsula to the north, is said to be an Ojibway word meaning "Waiting place," and was originally applied to this harbour. The harbour is a little horse-shoe-shaped bay, open to the north and north-east, but obstructed at its mouth by a sandy bar. The water within this bar is from four to five feet deep up to the beach of sand and gravel, which rises six feet above the water. Behind the beach is a narrow sandy plain, behind which is a thin row of elm, oak, maple and cherry. The centre of the island is a marsh covered with tall reeds, while most of the rest of the shore is surrounded by reeds or boulder-bars running out a considerable distance into the lake. Riding Mountain can be distinctly seen from this island as a clear blue line in the south-west.

West shore
north of
Narrows.

South of Cherry Island the west side of the lake to the Narrows is low, and without any sign of the underlying rock, but is composed of a ridge of gravel or boulders, lying on an original floor of boulder-clay, which has been first shoved up by the ice, and then assorted by the waves and currents. Many examples of

the result of the shoving of spring or floating ice were seen in 1889 in the little mounds of clay and gravel near the water's edge on the gently sloping shore just in front of the ridge of boulders ; and the gravel hook at the "Bluff Harbour" is an excellent example of the way in which this ice-shoved material is assorted by waves and currents, the finer pebbles being carried along into deeper water.

WATERHEN RIVER AND LAKE.

Waterhen River flows from Lake Winnipegosis into the north-western extremity of Lake Manitoba, touching the south end of Waterhen Lake about the middle of its course. Its Indian name, *Sin-gip-siew-sibi*, is given to it on account of the presence here of the western grebe (*Podiceps occidentalis*, Ojibway *Sin-gip-siew*), which breeds on the lake and river in quite large numbers.

The river was examined and surveyed by Henry B. Smith, C.E., in 1873, and the following are some of his notes in reference to it :—

"The total distance by this river between the above lakes (Winnipegosis and Manitoba) is thirty miles, and the difference of level 18·73 feet. After traversing a long reach of Lake Winnipegosis, the Waterhen River is entered, flowing in a north-easterly direction between low marshy banks, with a current of three miles an hour over a muddy bottom ; its average width is about 500 to 600 feet and depth five to six feet ; the difference of level on this section, known as the 'North Branch,' is about six feet.

"Waterhen Lake is now reached, a very shallow sheet of water, filled with boulders lying on a stiff clay bottom, and so close together that no channel can be found ; the average depth (in the channel) in July, 1872, was only three feet.

"Leaving Waterhen Lake the river flows at an average rate of from three to four miles an hour in a southerly direction to the 'Forks.' The depth varies from three and a half to seventeen feet, and the channel is in many places obstructed by large boulders, so as to interfere seriously with navigation.

"The average width of this portion of the river is about 500 feet, the bottom is stony as far as the 'Forks,' where it becomes muddy."*

In 1881 Thos. Guerin, C.E., examined the river for the purpose of determining the amount of water discharged by it, and reports as fol-

Volume
discharge.

*Memorandum on the portages and streams between Lakes Winnipeg, Manitoba, &c. From reports on surveys made by Henry B. Smith, C.E., in 1873. C. P. R. Report, Ottawa, 1874, p. 260, with map and section.

lows :—“ About five miles above its junction with the lake (Manitoba) a suitable place was found for examining it. Here the river was 444 feet wide ; its maximum depth was twelve feet, and the quantity of water passing in it was 13,930 cubic feet per second. From a watermark visible on its banks it was ascertained that the river had fallen $1\frac{65}{100}$ feet from its highest stage during the previous spring. When it was at that stage, the quantity of water passing in it was 18,642 cubic feet per second.”*

River banks.

In the upper parts of the river the banks are low, and generally skirted with reeds, though near Lake Winnipegosis the reeds are varied with grassy banks and occasional gravel beaches. At its mouth into Waterhen Lake the river is almost filled with rushes, and through them there is a narrow, rapid stream.

Another channel, to the east of the one usually travelled, is said to exist, but it was not examined.

In the lower part of the river are a number of islands, most of which are surrounded by rushes, and capped in the centre by groves of poplar. The banks are generally from three to eight feet in height, grassy on the face, but on top covered with the burnt remains of a forest of poplar and birch and small oak. Boulders of gneiss are scattered over the surface.

The river empties into Lake Manitoba by several channels, all of which wind through a low wide marsh for several miles.

Waterhen
Lake.

Waterhen Lake was examined by Mr. Dowling, who states that it is twenty-four miles long, with a width of five miles, a shore line of sixty miles, an area of forty-four square miles, and an elevation above the sea of 822 feet. It is very shallow, the depth in the centre being about six feet. The south-east side of the lake is thickly strewn with large boulders, but further to the north they are not so prevalent, though the beach is still low and sloping, partaking very much of the character of the east shore of Lake Winnipegosis north of Birch Island. The western shore is generally low and muddy, and often indefinite, being bounded by a wide bank of rushes. None of the underlying rocks were anywhere seen.

LAKE WINNIPEGOSIS.

Position.

Lake Winnipegosis is a long, curved lake, lying between north latitudes $51^{\circ} 34'$ and $53^{\circ} 11'$, and west longitudes $99^{\circ} 37'$ and $101^{\circ} 6'$. Its greatest length in a direction N. 30° W. from Meadow Portage to

Extent.

*Report on Lake Manitoba overflow, by Thomas Guerin. Report of the Minister of Public Works, 1867-1882, p. 541, Ottawa, 1883.

the mouth of Overflowing River, but across a long stretch of land, is one hundred and twenty-two miles; its greatest width, north of Fox Point, is seventeen miles and a half. It has a shore line of 570 miles, an area, exclusive of islands, of 2,000 square miles, while its islands have an aggregate area of ninety-six square miles. Its greatest ascertained depth is thirty-eight feet, off the north-east point of Birch Island, and its mean altitude is eighteen feet above Lake Manitoba, or 828 feet above the sea. This height is the approximate mean of two measurements made respectively by H. B. Smith, C.E.,* in 1873, and George A. Bayne, C.E.,† in 1889, the former finding a difference of level of 18·73 feet between the two lakes, and the latter a difference of 17·4 feet measured across Meadow Portage, when the water had been calm for some time.

The water in this lake is clearer than that in either Lakes Winnipeg or Manitoba, and, as was stated in referring to the latter lake, it is warmed by the sun's rays in summer, and as it does not cool rapidly, it exerts a great influence in equalizing the diurnal temperature of the country in its vicinity, and thus preventing the occurrence of summer frosts.

The following table will show the temperatures of the surface of the lake and vicinity during the summer of 1889, the observations having been generally taken in open water, some distance from land :—

WATER TEMPERATURE.

Date.	Time.	Temperature.	Remarks.
July 13.....		62 Fahr.	In Lake Winnipegosis.
14.....	9.05 a. m.	66	
15.....	8.00 a. m.	64	
16.....	8.20 a. m.	65	
18.....	7.40 a. m.	64	
19.....	1.40 p. m.	66	
20.....	8.35 a. m.	65	
21.....	8.45 a. m.	63	
22.....	3.15 p. m.	67	
23.....	11.30 a. m.	68	
24.....	11.30 a. m.	70	
25.....	7.00 a. m.	67	
29.....	10.15 a. m.	70	
31.....	12.00	70	
Aug. 3.....	9.00 a. m.	62	
6.....	8.00 a. m.	66	
7.....	3.30 p. m.	66	

*Memorandum on the portages and streams, &c., by Henry B. Smith, C. E., C.P.R. Report, 1874, p. 260.

†Letter from George A. Bayne, C.E., of Winnipeg, dated Dec. 26, 1890.

WATER TEMPERATURE—*Concluded.*

Water temper- ature— <i>Con.</i>	Date.	Time.	Temperature.	Remarks.
			,	
Aug.	8.....	7.20 a.m.	63	
	9.....	10.00	65	
	10.....		66	In Red Deer River.
	13.....		68	do do
	14.....	6.15 a.m.	70	do do
	14.....	10.50 a.m.	71	In Lake Winnipegosis.
	15.....	9.00 a.m.	69	
	17.....	7.45 a.m.	68	
	18.....	9.00 a.m.	68	In mouth of Shoal River.
	22.....	1.00 p.m.	69	In Swan Lake.
	27.....	5.00 p.m.	69	do
	31.....	12.30 p.m.	65	do
Sept.	1.....	1.50 p.m.	65	do
	2.....	7.20 a.m.	57	do
	3.....	2.00 p.m.	59	do
	6.....	5.30 p.m.	56	In Lake Winnipegosis.
	7.....	1.30 p.m.	56	
	8.....	9.00 a.m.	56	
	21.....	10.00 a.m.	48	
	22.....	9.30 a.m.	49	
	25.....	9.30 a.m.	44	
	26.....	8.30 a.m.	46 $\frac{1}{2}$	
	27.....	2.30 p.m.	47 $\frac{1}{2}$	
	28.....	11.00 a.m.	45	
Oct.	1.....	9.00 a.m.	41 $\frac{1}{2}$	
	3.....	9.30 a.m.	41	
	5.....	8.30 a.m.	41 $\frac{1}{2}$	
	6.....	11.45 a.m.	41	
	7.....	8.15 a.m.	41 $\frac{1}{2}$	
	10.....		42	
	12.....		43	
	14.....		42	In Waterhen Lake.
	19.....		40	In Lake Manitoba.
	22.....			Ice around the shore.

Ice.

The lake annually freezes over with a thickness of from two to three feet of ice, and, as far as could be learned, the dates of the opening and closing of navigation are about the same as those given for Lake Manitoba on pages 37 and 38.

Shores and Islands.

The following brief description of the shores and islands of the lake refers to the summer of 1889 unless otherwise stated.

Beginning at the south-eastern corner of the lake and proceeding northward, the shore is generally composed of a ridge of sand and gravel faced with scattered boulders, behind which is a marsh or low meadow from a quarter of a mile to a mile in width. East of the marsh or meadow is a light gravel ridge, on which are growing oak, willow and poplar, inclosing here and there small grassy swamps.

The Meadow Portage, between Lake Winnipegosis and Lake Manitoba, Meadow Portage. has its western termination in a little bay in this long coast meadow. The shore of this bay is free from boulders, and is a good landing place for canoes and small boats, but a number of stony reefs lie a short distance out in the shallow water. From the shore the portage road runs east across the level meadow for a quarter of a mile to a belt of oak and poplar. Passing through this grove it skirts the north end of an extensive marsh, passing here and there through clumps of trees, till a belt of poplar woods about a quarter of a mile wide is reached. Beyond this another swamp a third of a mile wide is crossed, and then the road enters a poplar forest stretching down to Lake Manitoba. Within this forest and about a mile and a third from Lake Winnipegosis is a low ridge, stated by H. B. Smith on his profile,* to be eleven feet above Lake Winnipegosis, or 29·72 feet above Lake Manitoba. Mr. Bayne informs me that the shortest distance between the two lakes is 9,400 feet. The land consists of a light gray, almost white, calcareous clay, holding many irregular pebbles of limestone. Very few boulders are lying on the surface, except at a point about two hundred yards east of the ridge last mentioned, where they are rather numerous.

The country maintains the same character throughout to the head of Waterhen River. The old trading post of the Hudson's Bay Company was situated on this shore, near the head of the river, but a few years ago it was moved down the river to a point just below Waterhen Lake.

From the head of Waterhen River to Point Brabant the east shore Waterhen River to Point Brabant. was examined by Mr. Dowling, and the following description is from his notes :—

The west side of the bay from which Waterhen River flows is very similar to the east side, being generally bounded by a beach of sand or gravel, behind which is a low flat meadow, extending back to a burnt forest of poplar and spruce. At a point half way down the side of the bay several small saline ponds lie behind the gravel beach, and at Salt Point there is a drier meadow, on which are the remains of several Salt Point. old houses. From this point a reef of boulders extends into the lake towards Ermine Island, which is generally high, and wooded with maple, its northern extremity extending into a gravel bar. Long Island, lying further southward within the bay, is low, and generally lightly covered with scrub. West of Salt Point the shore runs northward into a long marshy bay, to the west of which again is a low

*Memorandum on the Portages and Streams and C.P.R. Reports, 1874. Sheet 11
4

unwooded point, from which bars of granite boulders extend southward into the lake.

Turning northward up the east side of the main portion of the lake, the shore is generally low, with a few small boulders lying on scattered broken fragments of limestone. The timber, chiefly burnt poplar, first touches the beach two miles north of this point. Some of the bays are shallow, while the points are built up of large boulders, with deep water off them. Four miles and a half north of the point fixed rock was seen for the first time since entering the lake. Four miles and a half further north a small island lies off the shore wooded with poplar, elm and willow, while the land to the east is wooded with poplar, elm and a few oak trees.

At Net Point there is another low exposure of bedded limestone; but the rest of the shore all the way to Point Brabant is low and more or less closely piled with a ridge of boulders.

At Point Brabant a limestone cliff extends for about a mile along the shore, rising at its highest point to about forty feet above the water. A long sloping gravel beach reaches from the foot of the almost vertical cliff to the edge of the water, and on this beach, and under the shelter of the cliff, a line of wide-spreading elms is growing. A similar row of trees may be seen in front of many of the other cliffs by this lake, indicating clearly that its waves are not at present cutting them, but that they were formed when the lake stood a few feet above its present level, when the ridge along the top of the Meadow Portage was also formed, and when consequently lakes Winnipegosis and Manitoba were joined into one great sheet of water which extended to the south and east over large areas in the province.

For five miles north from Point Brabant the shore is often protected by a sloping wall of boulders, behind which is a higher ridge of boulders wooded with elm. At the end of the above distance is a low cliff of limestone, north-east of which and a short distance back from the lake, is a hill of limestone rising by an easy slope from the edge of the water to a height of sixty feet, and strewn with dead birch, spruce and poplar. Its summit is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, while its western face is strewn with large masses, some possibly in place, of heavily-bedded dolomitic limestone.

Wade Point.

From this hill to Wade Point, a distance of seven miles, the shore is everywhere low, and generally bounded by a wall of Archaean boulders, and wooded with elms, behind which is a country clothed with poplar and some spruce. Gun Island is a mass of these boulders ten

Rock exposure.

Point Brabant.

Old shore-cliff.

North of Point Brabant.

feet in height, and is connected with the shore by a long bar of similar boulders, which stood a foot above the surface of the lake during the period of low water in 1889.

North of Wade Point the character of the east shore changes considerably, and granite boulders, which form so prominent a feature of the beach to the south of it, are much less numerous, the boulder-strewn tract crossing the lake and continuing up the west side of Birch Island. The water to the south of Hunter's Island is everywhere shallow, and the shores slope very gradually into the lake. Boulders of gneiss are thickly scattered on the most southerly points. Elsewhere the beach is composed chiefly of more or less irregular fragments of limestone, which in most cases, as on the north side of Island Z, are probably derived from immediately underlying rock. North-east of Hunter's Island the beach is a belt, fifty to seventy-five yards in width, between the woods and the water, the upper part grass-grown, the lower part bare of vegetation, and scattered with debris, chiefly of moderately thin-bedded limestone with an occasional boulder of gneiss, all bedded in a soft light gray sandy clay.

In latitude $52^{\circ} 23'$ a hill of limestone, thirty-five feet in height, rises to the south of a shallow bay, and on its side sloping towards the lake is an old beach of rounded limestone gravel of the age of the Meadow Portage ridge.

From this hill northward to Point Laronde the shore is very monotonous, being everywhere very low, and composed of sandy clay irregularly strewn with fragments of limestone, and a few boulders of granite. The water off the shore is shallow, and stony bars project above its surface. The larger islands close to the shore are low, and wooded with spruce and poplar; their eastern sides are generally soft and marly, while their western sides are flat, like the main shore.

Further out in the lake several wooded islands lie in the channel between Birch Island and the shore; the most conspicuous and interesting of these is Hill Island, the northern one of the group. It rises about forty feet above the water, and at its northern end, hidden among poplar and spruce trees, is a half-buried cliff of limestone, at the foot of this cliff is a terrace strewn with boulders down to fifteen feet above the water, below which the beach is composed of a sloping pavement of granite boulders from twelve to eighteen inches in diameter. On the east side of the island is another cliff, but it consists of compact glacial till, and a beach of large boulders extends from its foot down to the lake. On top of the cliff, at heights of twelve and twenty-five feet above the water, are deposits of rounded gravel, indicating old stages in the history of the lake.

Change in
character of
shore.

Inland the island is generally thickly wooded with spruce, birch and poplar. From the north-east and north-west corners of the island gravel bars extend northward as reefs, and from the south end a gravel spit extends southward for 250 yards beyond the limit of the woods.

The other islands to the south are mostly low, with flat shores, and inland are generally wooded with poplar and a few spruce.

Low shore.

North of Point Laronde the east shore of the lake is everywhere low and flat, being often underlaid by thin-bedded limestone dipping gently towards the west, and running for a long distance under the water. This limestone has been very generally much broken by the shoving of the ice in spring, and the beach is therefore strewn with angular fragments of the rock. Two miles north of the point is the mouth of the only noticeable creek emptying into the east side of Lake Winnipegosis. It is fifty feet wide and from three to six inches deep, flows swiftly among boulders, and in the autumn of 1889 was falling about two feet over the beach into the lake. An Indian canoe route is said to go up this stream and across into a chain of lakes which connect with the northern end of Waterhen Lake, providing a short way to the Hudson's Bay Company's post on the latter lake, and one on which there is not much danger of detention by storms.

Canoe route.

Country east
of the lake.

The country through which this route passes, and the whole of the region lying between Lakes Winnipegosis and Winnipeg, is described by Alexander Monroe, the Hudson's Bay Company's trader at Waterhen River, as a great flat-lying area, dotted with many small lakes, and traversed from south to north by a high ridge covered with Balsam pine, reaching as far as the Grand Rapids on the Saskatchewan.

Islands and
points of
boulders.

The islands off the shore are generally capped by a ridge of granite boulders, and the whole shore bears evidence of having been moulded to some extent by the ice of the glacial period, for the points run out into the lake parallel to the direction of the glacial striation, while behind them are shallow bays extending back into long, narrow marshes. On the low, flat beach are also many evidences of the shoving of the ice in spring. Boulders are lying on the soft clay, and grooves in which they have been pushed along extend from them towards the water. One large boulder of dark gray gneiss had a groove behind it seventy-four paces, at least, in length; thirty-four paces straight, then a bend and twenty paces straight, and then another bend and twenty more paces straight, to beneath the surface of the water.

Long Point.

At the north end of the bay east of Long Point, and again north of the bay to the west of the same point, a high wooded ridge rises back

from the shore, and the north shore of the lake follows the foot of this ridge in a moderately even line to the mouth of Swamp Creek. The shore of the latter bay is low and marshy, and a number of rills of dark brown water are flowing into its western side from a dense spruce swamp. The beach is of fine hard quartz sand, and is generally skirted with rushes.

West of this bay, the beach for a short distance descends into even shore shallow water, and then for more than thirty miles it maintains a very constant character. It is generally about 150 feet wide, with a gentle slope between the water and the edge of the woods, while the water, even close to the shore, is of considerable depth. The beach, which is probably the most beautiful anywhere on the lake, is partly overgrown with grass, and is composed of sandy clay, in which cobbles and pebbles of white limestone are embedded, many of them but little water-worn and showing well-marked glacial striæ. Large boulders of gneiss are comparatively rare.

Towards the eastern end of this part of the shore the gentle slope between the edge of the grass and the water shows many evidences of ice shoving, both in little heaps of gravel piled on the beach, and deep furrows ploughed in the mud.

Behind the open shore is a forest of white and black poplar, mingled, ^{Wooded shore} in the distance, with birch and spruce. In this forest a hill rises by a gentle incline to a height of from sixty to ninety feet, and though its face is thickly overgrown with vegetation, some small boulders and cobbles, similar to those on the beach, can be seen lying on it here and there.

While none of the older rocks are exposed in place on this shore, ^{Old beaches} there are on the southern slope of the above-mentioned wooded ridge ^{and terraces.} several terraces and ancient gravel beaches which are of considerable interest. The most conspicuous of these terraces extends along the face of the ridge at a height of from twenty to thirty feet above the water. One of the localities at which it is best shown is four miles south-east of the Western Mossy Portage. It is here scarped, and is seen to be composed almost exclusively of flattened, disc-shaped, water-worn pebbles of white limestone, with a few of dolomite, and a few others of granite, most of which still show traces of glacial striæ. The pebbles are embedded in a scanty matrix of white, slightly clayey sand. The summit of the terrace is twenty-seven feet above the lake and consists of three gravel ridges, all of about the same height, and all parallel to the shore, separated by narrow troughs, the trough behind the third ridge being ten feet deep, back of which the main hill rises with a gentle slope. These probably repre-

sent the remains of an ancient gravel spit which projected into the lake in the era of the Meadow Portage ridge, and the long gravel islands opposite this part of the shore, and now a mile and a quarter out in the lake, possibly also represent fragments of the same ancient spit.

Four miles west of the Eastern Mossy Portage, the woods have been burnt for a short distance, and two terraces are seen, one about the height of the last, and one very conspicuous, at a height of from fifty to sixty feet above the lake.

Eastern
Mossy Port-
age.

Surveys.

The Eastern Mossy Portage, called by the Saulteux Indians *Kak-is-tét-i-nak*, The Man Ridge, starts from Lake Winnipegosis near the middle of this open stretch of shore line, and runs northward for a distance of about four miles to a shallow bay on the south side of Cedar Lake. It was first surveyed and levelled about the end of May, 1858, by Mr. A. W. Wells, acting as assistant to Mr. S. J. Dawson, who found that its total length was four miles and eighteen chains, and that Lake Winnipegosis was four feet higher than Cedar Lake, which was very low at the time.*

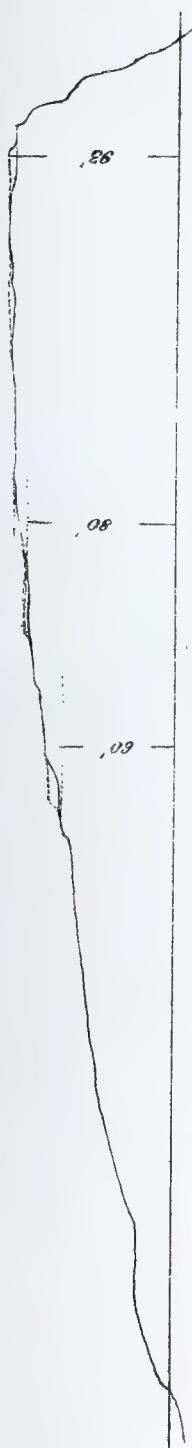
It was afterwards surveyed and levelled by Mr. Henry B. Smith, C.E., in 1873, and is described with a plan and section in his report as follows:—"The level of these lakes may be assumed to be equal. Starting from a fine open bay on Cedar Lake, with a bottom composed of mud and sand, sloping off gradually to a depth of six feet at a distance of 660 feet from the shore, the portage for three-quarters of a mile, passes over a corduroy road through a very soft muskeg or swamp, to a fine hard ridge of land, along which the Hudson's Bay Company have built their wagon road.

"The total length in a straight line between the lakes is nearly four miles. Travelling in a southerly direction from Cedar Lake the land rises gradually to a height of 93·14 feet at a point only one-quarter of a mile from the shore of Winnipegosis, then descends suddenly to its beach. Winnipegosis here presents a wide surface, affording no natural protection to boats from the heavy storms which are so frequent in these parts. The bottom of the lake, composed of limestone gravel, slopes away gradually to a depth of six feet at 200 feet from the shore."†

In the winter of 1880 Wm. Pearce, D.L.S., ran a survey line between the two lakes, crossing the portage a mile and a half from Lake

*Papers relative to the exploration of the country between Lake Superior and the Red River Settlement, London, Govt., 1859.

†Memorandum on the portages and streams, &c., by Henry B. Smith, C.E. C.P.R. Report, 1874, pp. 260-1.



Plan and Elevation of Mossy Portage between Cedar Lake and Lake Winnipegosis
From a survey by D.B. Throop in 1897.

Winnipegosis; in September, 1889, it was examined by the writer, and lastly, in July, 1891, it was levelled by Mr. D. B. Dowling, who found the highest point on the trail ninety-three feet above Lake Winnipegosis, and this lake nine inches above Cedar Lake. The accompanying plan and elevation are from his surveys.

Starting from Lake Winnipegosis, the portage runs from the water Description of over the beach-ridge, and immediately begins to ascend the hill, the top Portage. of which is reached on the third step at a height of ninety-three feet, where the ground is found to consist of water-worn discoidal limestone gravel. From this point it strikes northward along the top of a gravel ridge, which is at first wooded with spruce and then for a mile and a quarter with little else but Banksian pine, the land on either side being ten feet lower, and wooded with spruce and tamarack. The ridge throughout this distance is 100 to 200 feet wide, and consists of Gravel ridges. round or discoidal limestone gravel. It slopes lightly to the east, where in places there is a low subsidiary ridge, and as a rule descends somewhat more abruptly towards the west. In the woods to the east two other parallel and lower ridges were found, consisting of rounded limestone gravel, rising three or four feet above the surrounding country, and thickly wooded with spruce and poplar. The country is very wet, and covered with small spruce, tamarack and a few cedar, beneath which Indian tea (*Ledum latifolium*) and pitcher plant (*Sarracenia purpurea*) are growing in great abundance. In the above distance the portage ridge has declined from ninety-three to eighty-nine feet. It now drops slightly, and for the next quarter of a mile has an altitude of from eighty-two to eighty feet. Small spruce here begin to Descent to- crowd in towards the trail from either side, Banksian pine becomes wards Cedar scarce, and some cedar trees are noticeable in the swamps both to the Lake. east and west. The ridge now has the general appearance of becoming more diffuse, but Mr. Dowling recognized branching gravel ridges at altitudes of sixty and seventy feet, the latter extending as a gravel spit into the angle of the former, which is at the same level as the high terrace along the north shore of Lake Winnipegosis. North of this gravel ridge, which is two miles and a third from the shore of the last named lake, the road still continues along a belt of land somewhat higher than the surrounding country, and boulders of gneiss and limestone, chiefly the former, begin to appear. At a distance of two-thirds of a mile from Cedar Lake the ridge disappears altogether, at a height of thirty feet above the lake, and the road enters a wet swamp wooded with spruce, tamarack and cedar, across which the Hudson's Bay Company built a corduroy road of small poles, over which goods were conveyed in a waggon from lake to lake.

North end.

The north end of the portage opens on the shore of Cedar Lake, rising over a ridge of light red sand with a crest six feet above the water. The bay appears to be everywhere shallow, and a small lightly-wooded island of boulders lies across its mouth.

Ancient lake
beaches.

As will be seen from the above description, and the accompanying plan and elevation, the line of the portage road is along and across several ancient beaches, formed on an original ridge in the underlying till when the lake was at some of its higher stages. The top of the portage would represent the crest of an island, formed at a period when the lake was ninety-three feet above its present level, or 921 feet above the level of the sea. From this stage the water gradually declined, forming, while it was falling, two or three small beach-lines, till it reached a height of sixty feet above Winnipegosis, or 888 feet above the sea, when a strong ridge was formed, well shown both north and south of the higher portions of the portage, as well as in other places, showing that the lake stood at this level for a considerable period. From this latter level the water fell rapidly to a height of from twenty to thirty feet above Lake Winnipegosis, or about 850 feet above the sea, so that no beaches were formed on the portage ridge between these two elevations ; but at the latter, a gravel ridge extends along the face of the hill on the south side of the portage, while towards its north end the country, at about the same elevation, descends into a cedar swamp which slopes toward Cedar Lake.

Later history
of the lake.

This portage, therefore, furnishes a very interesting and concise history of Lake Winnipegosis in several of its later stages.

Western
Mossy Port-
age.

The Western Mossy Portage, called by the Indians *Muskegónigá* or the Mossy Portage, is used chiefly in winter by the Indians with dog trains. A paced survey was made of it by Mr. Dowling in 1889, and altitudes were determined by two aneroids. It starts from the open shore of Lake Winnipegosis, opposite Shannon Island, and ascends rapidly through woods of white and black poplar to a height of sixty feet, and then by a much more gentle incline through spruce and poplar to a total height of seventy-five feet at a distance of three-quarters of a mile from the lake. From here it slopes gently through a mossy swamp to the south-west angle of Cedar Lake near the mouth of a small creek ; the fore part of the distance being thickly wooded with small spruce, and the latter part with scattered tamarack.

The total length of the portage is about four miles and a quarter.

Depth of
water.

In Lake Winnipegosis a depth of eighteen feet can be obtained a short distance from the shore, while in Cedar Lake the water is so shallow for a long distance from the end of the portage that it is difficult to get to the land with a light canoe.

Swamp Creek empties into the lake at the edge of a very extensive Swamp Creek marsh, and south of this marsh a forest of spruce and poplar stands close to the shore, skirted by a narrow belt of grass growing on sand, pebbles and boulders. In front of this is a bare strip of sand and pebbles fifty feet in width, which shows many evidences of ice-shoving in troughs cut in the sand, and pebbles shoved back into little mounds.

All the way to the mouth of Overflowing River the shore is flat and uninteresting, the water off it being in places so shallow that it is difficult for a canoe drawing six inches to get within a quarter of a mile of land. It consists of a soft clayey sand, in which are imbedded, so as to completely cover the sand, pebbles of gneiss and fragments of limestone and dolomite. Behind this flat shore is a ridge of boulders of gneiss and limestone, raised to about the general level of the surrounding country, which, except at the prominent points, is wooded to within a short distance of the water.

Overflowing River is a small stream said to rise in Leaf Lake, just on the western side of the map. It flows first north-eastward and then south-eastward to its mouth at the north-western extremity of Lake Winnipegosis. Here it is 200 feet wide, with brownish water, in which, in September, 1889, there was no perceptible current. The shore adjoining it is low, with an open saline flat covered with grass and the red salt plant (*Salicornia herbacea*) to the north, and a forest of poplar and spruce to the south. Three-quarters of a mile up the river, the bank is abrupt and twelve feet in height, and a rapid is encountered with a fall of about three feet, where the water flows over a bed of boulders of gneiss and broken fragments of hard compact limestone. At the above date it was almost dry, but in August, 1888, Mr. Dowling ascended the stream with two large canoes for a distance of thirty-seven miles. He gives the following description of its characters :—

"At the first rapid a cut-bank on the south-east side shows six feet of stratified sand and gravel; at the next bend the bank is twelve feet high, and is composed of light gray clay, with a few striated pebbles; while at the end of two miles the banks have risen to a height of twenty feet. In this distance there are eight rapids of varying length, the uppermost and largest one having a fall of more than four feet, and they all seem to be caused by accumulations of boulders washed from the clay of the banks. Throughout this distance the timber on both sides of the stream is mostly fire-killed.

"Above the eighth rapid the river turns slightly more to the westward, still flowing through burnt country. The banks descend to an average height of about eight feet. The stream, though crooked, is deep,

and for six miles has a uniform current of about one mile an hour, and then, with a slight bend for a mile towards the north-west, it falls in the above distance down three small rapids. At the upper one of the series a dark yellow limestone was recognized in the bed of the stream.

"The next westerly bend opens to the view a fine straight stretch of river at least a mile in length, with a mean width of 300 feet, and apparently very deep. On either side is a narrow fringe of spruce and tamarack, behind which is a tamarack swamp.

Swamp and poplar forest.

"Above this straight portion of its course the river flows through a narrow strip of poplar woods, and then, coming from the northward for a distance of six miles, it winds in a very tortuous channel of twice the above length through a belt of mossy bog, which extends towards the north-east and south-west, and has an approximate width of three miles in a south-easterly and north-westerly direction. Ash, elm, poplar and willow occasionally overhang the stream.

Tributaries.

"Two small tributaries join the Overflowing River in this part of its course, one coming from the south-west through the middle of the bog, and the other from the north-east, draining a lake which can be seen from the extreme north-easterly bend of the river, and the shores of which appeared to be generally low and marshy.

"The river now turns sharply to the west, and for seven miles maintains the same tortuous character, but towards the end of this distance a current becomes appreciable, and the points of land included in the bends gradually become thickly wooded, till at last it leaves the bog and again enters the forest, when the banks suddenly rise to a height of at least twenty feet, and descend in a gravel-

Higher gravel covered slope to the water. Above this the river was ascended for banks and strong current two miles, but was found to be very shallow, and to have a strong current with a succession of small rapids, in which there was hardly enough water to float an empty canoe. The surrounding forest consists of large poplar, mixed with birch and some spruce of moderate size."

From the mouth of Overflowing River southward and eastward to Macoun Point the shore is for the most part grassy, sloping gently to the water, and in places fringed with rushes. Just within the edge of the woods a ridge, apparently composed of gravel, runs parallel with the beach. About the middle of the distance, or six miles from the mouth of the river, a long bare diffuse point extends into the lake. It is composed chiefly of sand and limestone gravel, but the end, which is a little higher than the rest, is piled round with Archæan boulders.

Macoun Point.

Macoun Point is wooded with a beautiful grove of large elms. Around the grove is a beach of rounded limestone gravel, and in front

of and a little below this beach is a line of boulders of gneiss and limestone, some of which show glacial striae. From the foot of this line of boulders the shore extends with a very gentle slope to the edge of the water, and is strewn with angular fragments of porous dolomite broken from the parent rock beneath, and shoved over it by flow ice. The rock here seen in place is the first met with on the shore since leaving Ami Island at the north-east corner of the lake.

From Macoun Point southward to the mouth of Red Deer River the Dawson Bay. shore is very irregular, and the more prominent headlands are formed of cliffs of light gray limestone. The shores of the bays are low and composed of clayey sand or broken pebbles, and are commonly margined with rushes. At the bottom of the deepest bay is a bare saline area around some salt springs, and this again is surrounded by the usual growth of thin wiry grass. These salt springs are the most northern that were observed on the west side of the lake.

Red Deer River flows into the west side of Dawson Bay just north Red Deer River. of a small club-shaped peninsula, terminating in a low wooded point underlain by white dolomitic limestone. The channel at its mouth is from three to twelve feet deep, not being obstructed by bars of sand or gravel. It has a width of from 200 to 300 feet, and banks three feet high, behind which, on the north side, is a meadow covered with rich grasses and vetches. Back of this is a forest of poplar and spruce, which shows many traces of the ravages of fire.

From the mouth of Red Deer River to Whiteaves Point the shore is very irregular. In many places it consists of cliffs of Devonian limestone which have been formed when the lake was at the stage of the Meadow Portage ridge, and are now in many cases behind narrow belts of timber. These will be found more fully described on subsequent pages.

Seven miles south of Red Deer River is a shallow bay, almost cut off from the rest of the lake by a long straight spit of rounded gravel shaded by a line of spreading elm trees; and at the bottom of the bay is the mouth of Steep Rock River. This river is said to rise in two Steep Rock River. lakes on the summit of Porcupine Mountain, and to flow down its face in a gorge that can be clearly seen from the islands in Dawson Bay. On reaching the level country it opens into a marshy lake, or wide marsh, surrounded by tall spruce and covered with cat-tail and other rushes. Through this marsh it winds with ill-defined banks, and then appears to flow from its south-east end as a shallow stony stream. In ascending or descending this river with canoes the Indians make use of a good portage path 1,650 paces in length, cut out through a forest of spruce and poplar on the north side of the river, from the

marsh to the lower end of the rapids. The river at the latter point is forty feet wide and eight inches deep, flowing with a swift current over stones and little gravel bars, and the water appears to be slightly saline. For the rest of the way to the lake it has little or no current, and the banks are wooded for a short distance, and then are low, marshy, and skirted with willows.

Bell River.

Five miles and a half south-east of the mouth of Steep Rock River, Bell River flows into the bottom of another shallow bay. This river rises on the summit of Porcupine Mountain, and flowing eastward in the bottom of a gorge in the face of the mountain turns northward and empties into the south-west corner of Dawson Bay. Its upper course is described on a subsequent page, but at its mouth it is thirty feet wide and eighteen inches deep, with a bed obstructed by large boulders of Archæan gneiss, large and small irregular fragments of Devonian limestone and a few of white Dakota sandstone.

Islands.

The islands in Dawson Bay are all well wooded, and most of them are immediately underlaid by white limestone, which often projects from among the trees in bold vertical cliffs.

Professor Macoun's description.

Prof. Macoun, who visited this lake in 1881, speaks of this portion of it as follows :*—

"The northern end of Lake Winnipegosis is filled with lovely islands, which are margined with fine drooping elms of a large size. The sail across Dawson Bay on a lovely day in July reveals more natural beauties than I ever before beheld on our inland waters. Green islands, with white sand or gravel beaches, covered with drooping elms and other fine trees, the mainland rising gradually up from the water covered with an unbroken front of tall poplars intermixing with the gloomy spruce, deep bays backed with the distant forest, and high over all the steep escarpment of Porcupine Mountain, form a picture, as seen from the lake, which has few equals in any part of the world. Point Wilkins, a bold promontory pushing out into the bay, and rising almost perpendicularly to a height of seventy (83) feet, is a prominent and beautiful object. Crossing a bay to the north of this, and rounding a low point, we entered the mouth of Red Deer River and, after ascending it a mile or more, camped at a salt spring, where the swift water commences."

Whiteaves Point.

On the east side of Dawson Bay, at Whiteaves Point, a cliff of highly fossiliferous limestone rises to a height of thirty feet above the water, but is now hidden by a belt of elms fifty feet in width at the back of the gravel beach. Off the point is a small horse-shoe shaped island,

* Report of Explorations by Professor John Macoun, M.A., F.L.S. Ann. Rept. Dept. of Interior, 1881, p. 75. Ottawa, Govt., 1882.

composed of rounded pebbles of limestone, at which boats bound down the lake usually stop to take on ballast.

North of Whiteaves Point is a wide bay, in which lie several islands wooded with elm, poplar and willow. The outermost island is a high limestone rock facing the west in white vertical or overhanging cliffs, and diminishing towards the south to a gravel spit. Those of the group at the bottom of the bay are mostly low, and composed of pebbles and irregular masses of white dolomitic limestone mingled with boulders of gneiss.

The shore opposite these islands is generally low, but rises gradually to a height of twenty-five feet within woods of large spruce and poplar, under which is a close thicket of spicated maple (*A. spicatum*). Northward to Nason Point the country, though low, continues thickly wooded, and from the edge of the woods a narrow grassy belt slopes gradually to the deep water. At the points, the beach is flat, and scattered with fragments of limestone.

From Nason Point, across the north end of the peninsula east of Dawson Bay, to Channel Island, the country is wooded with spruce and poplar, and between the woods and the water is a narrow, flat-lying belt of grassy and stony land. Over this the ice shoves in spring back to a ridge of large and small irregular fragments of rock. At one point, on the south-west side of Cameron Bay, a cliff of limestone thirty-seven feet high, peeping out from behind a narrow belt of small poplars, breaks the general monotony of the low-lying shore.

Many low islands lie in the channel north of this peninsula, all with flat-lying shores, occasionally strewn with a few boulders. No cliffs of rock are anywhere to be seen. All are wooded with belts of timber, usually spruce and poplar. Of these, the largest is Spruce Island, and next to it in size is Channel Island, which is almost joined to the shore by a narrow neck of meadow land, across the north end of which is a channel fifty feet wide much obstructed by boulders of gneiss. It is at times difficult to take a canoe through this channel, for in some seasons a depth of but a few inches of water can be found in it.

Shannon Island is also low and wooded, but a group of three small islands lying midway between this and Channel Island is of somewhat greater interest than the rest. They consist of bars of gravel, forming crests along the summit of reefs or low-lying islands of boulder-clay, and clearly illustrate the combined action of water and ice in forming the present shore features of the lake. The middle island, which is probably the most conspicuous, is a long, crescentic bar of

water-worn limestone pebbles, very free from any mixture of clayey material. It is a mile long, 120 feet wide, and twelve feet high in the middle, where it supports a few willows and stunted elms. To the east the water is shallow for a very short distance, and then descends to a considerable depth, while to the west the shallow water extends for a comparatively long distance, leaving the bar along the eastern side of the shoal. Gneissoid boulders are scattered at the foot of the bar, and in this shallow water, especially at the north end of the island and in the immediate vicinity, a little quartz sand may also be seen in a couple of places near the water's edge.

Towards its north end the bar declines gradually to the edge of the water, and continues just beneath its surface to the point of a similar but smaller gravel island to the north.

The most southern of the three islands is divided from the middle one by a narrow strait of moderately deep water, and its northern point is composed, at the water's edge, of irregular, broken fragments of limestone with a few boulders of gneiss. The north-eastern side of the island is a gently curved bar of limestone gravel, wooded with elm and poplar; while to the south-west of this bar is a low flat, but little above the water, covered with irregular fragments of limestone and scantily overgrown with grass.

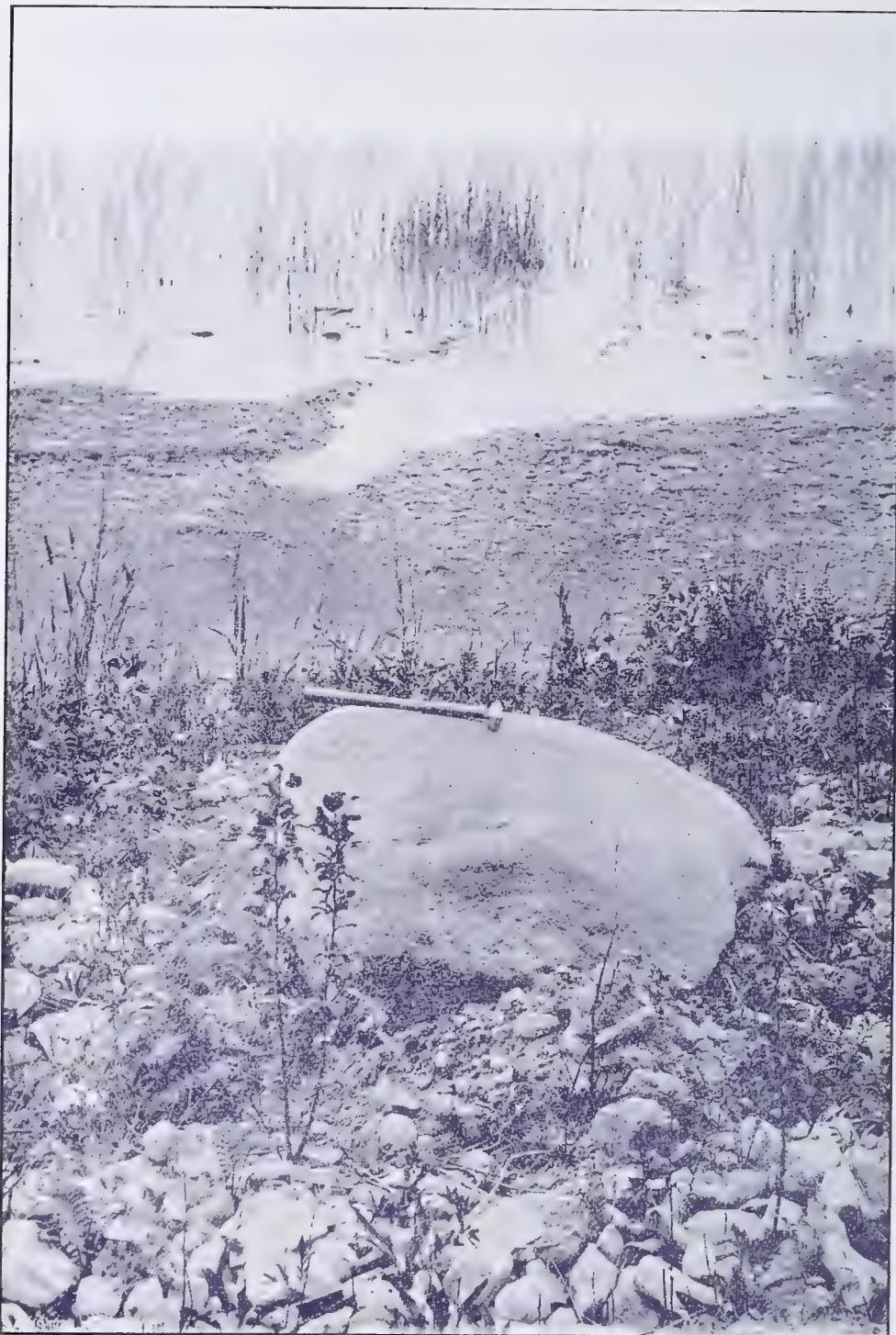
Mode of formation.

The mode of formation of the gravel bars is apparent from a consideration of the above-described characters. We have seen that the spring ice everywhere scrapes the low-lying shores of the lake, and shoves the collected debris before it into a ridge, which is often almost out of the reach of the water, the pebbles in which are therefore but slightly rounded, and are mixed with much clay and sand. In this part of the lake there have originally been islands of till or stony clay rising to about the level of the water, the southern one being still above the low water stage. The shoving of the ice in spring, out of Dawson Bay into the body of the lake, scrapes the surface of the low stony islands, and carries the collected material to their eastern side. Here the waves from the open lake beat against it, wash out the fine material, and pile the now rounded and assorted pebbles into an even ridge.

Pelican Bay.

East of Channel Island, Pelican Bay, a long shallow arm of the lake, extends southward for a distance of twenty-five miles, and its shores being low, and but little affected by waves and currents, show many beautiful examples of the influence of ice.

For sixteen miles down the west side of the bay the shore is low, with a width of from fifty to two hundred yards of bare marly flats between the water and the spruce and poplar forest. On this flat



J. B. Tyrrell, Photo., July 20, 1889.

ICE-SHOVED BOULDER WITH CURVED GROOVE, SHOWING ITS TRACK FROM OUT
IN THE WATER, WITH THE SMALL STONES PUSHED IN FRONT OF IT.

PELICAN BAY, LAKE WINNIPEGOSIS.

are lying boulders of gneiss and fragments of Silurian and Devonian limestone. At one point there is a boulder of Devonian limestone nine feet long, eight feet wide and six feet high, with smoothed and well glaciated sides and corners, lying one hundred feet from the water. It has recently been moved at least ten feet, as a groove of this length runs out from it towards the water, while on its opposite side boulders and small stones are piled against it to half its height.

At the end of the sixteen miles a hill of limestone rises to a height of twenty-six feet and a half behind a skirting of small poplar and birch. The surface of the limestone has been smoothly glaciated, but has been so much corroded by vegetation that I was unable to detect any striæ.

Five miles south-east of the limestone hill, and at the second Narrows in the Bay, a point projects from the low shore. It is essentially composed of sandy clay scattered over with irregular angular fragments of limestone, with which are mingled a few nodules of chert and iron pyrites. In a few places on the bar is some small rounded gravel.

The bar is broken by several hollows, in which many large boulders of gneiss are lying. Some of them, especially those lying on higher ground, show clear evidence of having been shoved up by the ice. A large one, 5 ft. x 4 ft. 10 in. x 4 ft. has a groove fifty-six feet long running down from it in a direction S. 80° E., while on its opposite side is a pile of gravel and small boulders. The groove is in places eighteen inches deep, with clay and small stones piled up as a ridge on each side.

Also near the base of the bar is a large transported boulder of dark gray biotite granite, of the typical glacial shape, with smooth, even or slightly grooved sides and rough ends. It has a greatest length of nineteen feet three inches, a greatest width of nine feet five inches, and a height above the ground of six feet eight inches.

Two miles south of this bar, and a quarter of a mile back from the Salt spring shore, among woods of small spruce, is a considerable tract of arid land covered with a crust of salt, from which the almost dry channel of a small saline brook descends to the lake.

This the third, or most southern division of Pelican Bay, is everywhere very shallow, and boulders are projecting out of the water at a distance of from a quarter to half a mile from the shore, which consists of mud flats, thickly scattered over with fragments of white limestone and grooved by lake ice. Back from the lake there is a large amount of good spruce.

Pelican Creek, a shallow stream, about forty feet wide, empties into Pelican Creek. the south-west angle of the bay. It is said to flow from a lake a short

distance in the interior, known as Pelican Lake. In July, 1889, the creek was ascended in a canoe for a quarter of a mile to a stony rapid, where there was only a little water trickling among the stones. On the east side of the mouth of the creek, and a third of a mile back from the bay, is a bare hill about thirty feet high surrounded by groves of small spruce and poplar. Its face is scattered with large boulders, while on its summit, which extends as a ridge in a direction N. 75° E., are several springs of brine described on a succeeding page. This ridge is a quarter of a mile long, and slopes to the south in a narrow opening through the woods to a wide arid plain. The subsoil appears to consist of broken fragments of white limestone.

Salt springs.

Ice-shoved
boulders.

Returning northward down the east side of Pelican Bay the water in the southern division is so shallow that it is practically impossible to reach the land with a large canoe, and in the second or middle division the water is also very shallow, the bottom of soft sandy clay scattered with fragments of limestone and a few nodules of iron pyrites. Many of the former have one smooth side covered with glacial striæ, and are evidently derived from the till. In this protected bay, and especially on its north side, which is bordered by a fringe of rushes, are some of the best examples of ice-grooving that have ever come under the writer's observation. Boulders are lying here and there, and most of them show signs of having been moved from three inches up to thirty-three paces. The sand and pebbles of the beach are generally piled up on their landward side, while a groove extends towards the lake. The majority of the shorter grooves on the north shore trend N. 60° to 75° W. One, ten paces long, trends N. 10° W., and in this the boulder is seen to have at first lain transversely to the direction of the groove, and to have been turned round and shoved with its greater axis along the groove. A group of six boulders have been shoved in a direction S. 70° W. Another boulder 44 x 45 x 22 inches has taken the following course, turning sharply at the changes of direction: From its starting place in the water N. 50° W. for fourteen feet six inches, then N. 10° W. thirty-seven feet, then N. 40° W. thirteen feet six inches, then N. 25° W. ten feet eight inches to the stone. Another boulder is now lying in the water at the end of a straight groove about fifty feet long, running from it in a direction N. 35° W. towards the shore, and pebbles are piled up on its lakeward side, showing that it has been shoved out from the shore when the ice was carried out by the wind. The shore throughout this distance has a constant direction S. 50° W.

The irregularity in length and direction of these grooves on a soft, straight shore shows clearly that they are caused by the irregular



J. B. Tyrrell, Photo., July 20, 1889.

ICE-SHOVED BOULDER, AND GROOVE BEHIND IT 30 FEET LONG, SHOWING ITS
TRACK UP THE GENTLY SLOPING BEACH.
PELICAN BAY, LAKE WINNIPEGOSIS.

pressure of broken ice in the spring, rather than by the regular expansion of the ice during the winter with the variations of the temperature.

Behind this low beach is a wall of boulders that have been shoved back against the higher ground within the edge of the woods, and have reached their permanent resting place, where they can no longer be affected to any considerable extent by the waves and ice of the present lake. Within the woods is a ridge twenty feet high scattered with gneissoid boulders. Ridge of boulders.

In the mouth of Pelican Bay are a number of low but beautifully wooded islands, with shores of clay and boulders running out into spits of limestone gravel.

From Whiskey Jack Point, which lies at the eastern side of the entrance to the bay, the shore turns towards the south-east, and for five miles is composed of water-worn gravel along the face of a forest of spruce and poplar. Within the forest a ridge rises to a height of twenty-five feet above the water, and its summit is strewn with large boulders of gneiss. In summer the trees close to the beach are everywhere wound with the webs of innumerable spiders, set to entrap the swarms of waterflies bred in the lake. Whiskey Jack Point.

For another five miles, to Devil's Point, the shore is low and sloping, and composed of clay scattered over with fragments of white limestone with very few boulders, behind which is an ice-shoved ridge of irregular gravel.

Devil's Point is a relatively high, rounded promontory, extending Devil's Point. northward towards Grand Island, from an elevated portion of the mainland. On its western side rock appears in place at the water's edge, while in other places the beach is piled to a height of sixteen feet with rounded masses of rock, over which is a grove of birch and poplar. Behind this grove is a cliff of limestone thirteen feet high, and above the cliff the land inclines gently upwards to a total height of forty-five feet. Along the western face of this slope a few large boulders of gneiss are lying, and its crest is composed of more or less rounded pebbles and cobbles of limestone.

Grand Island, to the north of this point, has a general wedge-like shape, with a greatest length of five miles and a quarter and a greatest breadth of two miles. It is thickly timbered throughout, and while its northern and eastern sides slope gradually to the water, its western side rises in a cliff to a height of fifty feet, on the top of which is a gravel ridge with a total height of fifty-five feet above the lake. This evidently represents a portion of the same shore line that has already been seen at Devil's Point and on Mossy Portage, having

here formed the crest or point of an island standing out in the middle of Lake Agassiz.

Cormorant Islands

East of Grand Island lie the Cormorant Islands, the largest of which is wooded, while the others are bare, stony bars, on which great numbers of cormorants and pelicans annually rear their young. They consist of boulders of gneiss and limestone and nodules of iron pyrites.

Hill on shore.

From Devil's Point the shore turns southward for eighty-five miles, forming the western side of the main portion of Lake Winnipegosis. For the first ten miles the beach is low and muddy, with a ridge of boulders or fragments of limestone back from the water along the edge of a tract of low-lying land covered with small burnt timber. Near a point at the south end of this distance a ridge twenty-eight feet high, covered with burnt and partly fallen spruce and poplar, runs east and west behind the low beach, and consists on the surface of large and small rounded or partly rounded water-worn fragments of limestone with a few boulders of gneiss.

Between this hill and Fox Point is a bay surrounded by low shores wooded with fire-killed poplar and small spruce. In the mouth of the bay is a wooded island, between which and the latter point the lake has a depth of from fourteen to seventeen feet.

Pemican Island.

Six miles and a half north of Fox Point Pemican Island rises from the lake at a distance of more than two miles from shore. It has a greatest length of about three-quarters of a mile, and consists of a wooded limestone hill rising to a height of forty feet above the lake. On its northern side it is surrounded by a beach of closely-packed boulders of gneiss, while to the south and east the shore is flat, and behind it, within a belt of elm and maple, is a cliff of limestone. Towards the south-west the island is terminated by a long, naked spit of limestone gravel rising three feet above the water. The occurrence of fragments of lignite on this bar and on the adjoining beach has long been known to the Indians, and they assert that it is washed up out of the lake by every storm. It is doubtless derived from an outlier of Cretaceous sands or shales lying just beneath the surface of the water on the south side of this island.

North Manitou Island.

North Manitou Island lies four miles south-east of Fox Point, and the water throughout the distance between them has a general depth of from twenty-four to twenty-six feet, with a muddy bottom. The island has once been wooded with very large spruce, birch, poplar and elm, but most of the trees are dead and falling. The shore on its north side is a narrow belt of limestone fragments, stretching to the water from the foot of an ancient low cliff, now sloping and covered with vegetation. At the north-east point

there is a steep wall of closely piled boulders ten feet in height. The east side is a narrow beach of limestone gravel, while the west side is muddy, and slopes off into shallow water. From the south point a spit of limestone gravel extends southward for a third of a mile, and from its termination a narrow, shallow bar extends a long distance towards Birch Island.

Birch Island is a large land area lying in the middle of Lake Win- Birch Island. nipegosis, and approaching to within a short distance of both its eastern and western shores, thus dividing it more or less completely into two parts. It has a greatest length of seventeen miles, a greatest breadth of five miles and a total area of seventy-four square miles. It has formerly been well timbered, but as far as can be determined from the shore, the timber has all been destroyed by fire, and none of any value remains.

At Roderick Point, on its north shore, low cliffs of limestone rise above the gravel beach. The remaining shores are generally low, the west and south sides being thickly strewn with boulders of gneiss, with long stony points occasionally running out towards the south.

West of Birch Island a number of small islands lie in and obstruct "Drumlins." the channel. They are all composed more or less entirely of boulders, and are elongated in the direction in which the Manitoban lobe of the Laurentide glacier has moved across this whole area, being of the nature of Drumlins or raised ridges of till. As a rule, a belt of elm and poplar is growing along their crests.

From Birch Island to Duck Bay the west side of the lake is gener- Camping Islands. ally low, and often has a beach of gravel with boulder points. Off Duck Bay the Camping Islands are very similar to those already described lying west of Birch Island, and consist essentially of ridges of boulders lying parallel to the direction of glaciation. The ridges rise in places to heights of twelve feet above the lake, and they are often worn down by the waves into bars of rounded gravel. Their crests are wooded with small groves of poplar, spruce, elm and ash-leaved maple.

Duck Bay is little more than a westward continuation of this group Duck Bay. of islands. It consists of several shallow lakes connected by narrow arms, which run out towards the north and south into extensive marshes. Through one of these marshes the South Duck River flows for a considerable distance in a well-defined channel 100 feet wide before it empties into the "bay," while the North Duck River joins the most westerly portion of the open water as a brook with dry grassy banks. A short distance above its mouth, near where it emerges from the spruce forest, it is fifty feet wide and three feet deep, with a slight current.

Old trading post.

The point south of the entrance to Duck Bay is a bar of boulders 150 yards in length piled regularly to a height of eight feet above the water. A gently rounding bay stretches southward from this point, the shore of which is chiefly composed of pebbles of limestone with a few boulders of gneiss. Near the bottom of this bay, seventy yards back from the lake, an old abandoned trading post of the Hudson's Bay Company is very prettily situated in poplar woods.

From Duck Bay southward to Pine River, a distance of about eleven miles, the beach is composed of sand or gravel, behind which is a wall of boulders, and the salient points are also entirely surrounded by boulders. On the ridge thus formed a row of poplar and ash is growing, behind which a low meadow extends for a short distance to a forest.

Pine River.

Pine River, for a mile and a half up from its mouth, is about one hundred feet wide and from three to five feet deep, with dark, brackish water, without perceptible current. The banks are low and mostly grassy, and back of them are forests of poplar and spruce. At the head of this navigable stretch is a rapid down which the river flows through an accumulation of large boulders of gneiss, and a short distance below this rapid the Hudson's Bay Company have a trading store on the west bank, which was built in the autumn of 1887, when the store at Duck Bay was abandoned. Below this store, but on the east bank, the Roman Catholics have a church and mission school. On the west bank of the river half a mile above its mouth, is a bare, salty plain, in the middle of which are several springs of brine. The springs are surrounded by broken masses of limestone and boulders of gneiss, while the ground generally is a soft, springy mud.

Sagemace Bay.

From Pine River, Sagemace Bay stretches southward for twenty-five miles, and is separated from the main body of the lake by the point of land known as Red Deer Peninsula. Its shores and islands are everywhere low, and without any signs of the underlying limestone. The beach on its eastern side is composed chiefly of boulders from four to eighteen inches in diameter, with a few limestone pebbles, except in two or three of the most sheltered bays, where short, sandy beaches are found. In some places the larger boulders, which are mostly of gneiss, are piled in an evenly sloping wall, but in the majority of places the smaller boulders of gneiss and limestone are scattered on a slight incline down to the lake, while the larger ones lie near the roots of the trees at the level of the highest stages of the water. Off the shore the water is generally moderately deep and free from weeds. The southern and western sides of the bay are shallow, and, except at the points, are fringed with narrow bands of rushes. The beach is a ridge of small

gravel, with boulders along its crest, and is covered with grass, deciduous plants and small berry bushes. Poplar, oak and willow form small groves all along the shore.

The islands are all very similar in character. The interiors are wooded, the larger ones with spruce as well as poplar. The shores are composed of sand and boulders, and are occasionally fringed with rushes in the more sheltered places.

Red Deer Point is surrounded by a wall of boulders of gneiss and limestone, and the low island to the north of it is simply a boulder reef. Red Deer Point.

From this point southward to the mouth of Mossy River, a distance of twenty-nine miles, the shore is very irregular, being broken by narrow bays and long gravel or boulder points. Low cliffs of limestone occasionally overhang the lake in the first half of the distance, but most of the salient points throughout are composed of boulders. The bays have beaches of more or less rounded gravel, in front of which a sloping boulder pavement sometimes stretches to the water.

At a point six miles north of Mossy River the straight beach is composed of small boulders and pebbles of gneiss and limestone. A hundred feet back from the water the shore rises in a low ridge of rounded gravel wooded with a few small willows. Behind this ridge a grassy prairie stretches westward for a quarter of a mile, to several springs of brine, rising in the distance about eight feet. To the north it is bounded by a grove of poplar and small oak, while to the south the poplar is mixed with spruce. On an arid, salty plain to the west are the ruins of several old houses where Monkman and others used to live when they supplied the Red River colony with salt, and the remains of iron pans in which the brine was boiled down. These salt springs will be treated of more fully on a subsequent page.

From the mouth of Mossy River eastward to Meadow Portage, a distance of thirteen miles, the south shore of the lake is everywhere low, and surrounded by a naked wall of boulders; while in the rounded bays between the points the beach is occasionally a closely-packed boulder pavement sloping up at an angle of about 15° to a wave-formed gravel ridge, or in other places boulders are more thinly and irregularly scattered in front of this ridge. On the ridge itself there is usually a narrow belt of maple, elm, ash and oak, while behind it a low-lying marsh stretches back to the poplar forest.

LAKE DAUPHIN.

Lake Dauphin lies in the midst of an alluvial plain about nine miles south of Lake Winnipegosis, into which it is discharged by the Mossy Position and extent.

River. It has a greatest length of twenty-six miles, a greatest breadth of eleven miles, a shore line of sixty-four miles, and an area of one hundred and ninety-six square miles. Its greatest ascertained depth is twelve feet and its approximative elevation, deduced from barometric readings and the estimated fall of Mossy River, is eight hundred and sixty feet above the sea.

History.

Its name is associated with the earliest explorations in the North-west, since Fort Dauphin, one of the trading establishments of the French before the cession of Canada to Great Britain, appears to have been situated on its shore, and probably near its north-western extremity. This fort was founded in the autumn of 1741 by Pierre, one of the sons of Sieur de la Verendrye, who travelled northward from Fort la Reine (Portage la Prairie) across Prairie Portage into Lake Manitoba, and thence probably by the old canoe route to Lake Dauphin*.

Ruins of old forts.

At the present time ruins of old trading posts of the Hudson's Bay Company can be seen on the west side of the lake, eight miles south of the mouth of Valley River, and at the edge of the forest at the south-east angle of the lake.

Low shores.

The shores of the lake are everywhere low, and show no exposures of the underlying Palaeozoic rocks. The projecting points, except those formed by the tributary streams, are composed entirely of boulders, which on the south side run out as comparatively long, narrow arms into the water, while on the east side they are merely gently-rounded prominences. Between the points the west and south shores are very low, and are surrounded by a sand and gravel beach, extending back into a marsh. The east shore often presents to the lake a regularly built embankment of boulders or cobble-stones, behind which there is occasionally a low cliff of light gray till with boulders. Elm, ash, oak and maple are growing on top of the beach, and in the background is often an open forest of poplar.

Five small streams empty into the south and west sides of the lake, most of which rise on the summit or eastern face of the Riding Mountain and flow across the rich alluvial plain between the mountain and lake.

*P. Margry. *Mémoires et Documents, &c.* Vol. 6, pp. 591, 594 and 617. Bougainville states that "80 lieues from La Reine (the fort) is situated on the River Minanghenachequeké or de l'eau trouble" evidently Mossy River, as the name given me by the Indians for this stream was Minākweniskegow, which is clearly the same word. P. Margry. Vol. 4.

Peter Pond, who appears to have been the first Englishman to occupy this fort after it was abandoned by the French, gives the location of the post occupied by him in 1775 at the north-west angle of the lake. P. Pond's Map of 1785. Can. Arch., 1889, p. 53.

For other references to this post see "Henry's Travels," p. 260. "Harmon's Journal," p. 52. Alex. Mackenzie's History of the Fur Trade. Alex. Henry Ms. in Parliamentary Library.

Turtle River is the most southern of these five streams. It is stated Turtle River, to rise in small brooks on the eastern face of the mountain and in some extensive marshes on the plain to the east. At the crossing of the cart trail to Lake Manitoba, the creek, in October, 1889, was twenty feet wide in a winding channel twelve feet deep. The bottom was stony, and the banks were wooded with poplar, elm and willow. Here a thriving Métis settlement has been established within the last few years. From this point to the lake the adjoining country is generally a level, grassy plain, and at its mouth the river is fifty feet wide and from two to four feet deep, emptying into the lake over a shallow sand bar.

The trail mentioned above runs for about seven miles through undulating country dotted with poplar groves, at first ascending a gradual slope scattered with boulders of gneiss, &c. It then enters the poplar forest, through which it is cut eastward to Ebb and Flow Lake. The surface continues generally undulating, and appears to be underlaid directly by light gray till. In range 13 the trail reaches a small ridge of rounded gravel five feet high and 250 feet wide, along which the old trail followed by Prof. H. Y. Hind in 1858 is stated to Old trail. run for several miles, and which here joins the trail now used. The ridge comes from the north-west, and a quarter of a mile to the south-east it ends in a rounded point, beyond which is a level, grassy plain. The elevation of this ridge, as determined by several aneroid readings, is 933 feet above the sea. From this ridge, on which we had camped for the night, the trail runs for about 150 yards on an ill-defined ridge trending north-east, and then turns eastward on an open, narrow, well-rounded ridge of small gravel, on the south side of which is a meadow, while to the north is a lower country wooded with spruce and tamarack. The face of this ridge or old beach is thickly scattered with boulders; it soon turns to the north and may continue for a long distance, but the trail leaves it and descends into the woods. Near the eastern side of range 13 the trail crosses another well-defined ridge, consisting of sand and small rounded pebbles of limestone. It runs N. 50° W. and S. 50° E., is four feet high and 150 feet wide, and has an approximate elevation of 910 feet above the sea. Gravel ridge.

From this ridge the trail runs north-eastward for two miles and then turns south-east and runs for a mile or more along the face of a light slope thinly wooded with small oaks. This is also an old shore line, and has an approximate elevation of 875 feet above the sea, being probably the same as the 60-foot beach around Lake Winnipegosis.

Ochre and Vermilion rivers rise on the summit of Riding Mountain Ochre and and flow down its eastern face in deep valleys that will be more fully Vermilion described in the strictly geological part of the report. The first named rivers.

stream flows through woods to within a short distance of its mouth, while the Vermilion winds across the partly-wooded plains in a channel overhung by a belt of elm and maple.

Wilson River. Wilson River was not followed to its source, but it appears to rise on the north-eastern face of the mountain, where the escarpment is a longer and more gentle slope than usual, and thence it flows eastward across the level of Lake Dauphin plain to empty into the west side of the lake two miles north of the mouth of Vermilion River.

Valley River. The last and largest of the five streams is Valley River, which is stated to rise in Singoosh Lake in the interior of Duck Mountain, and thence flows southward through Angling Lakes into the bell-shaped valley that separates the Riding from the Duck Mountain. Near where it enters the valley it is joined by Short Creek flowing from the west in a deep, narrow valley, which connects at its western Indian village end with the valley of Shell River. Here there is a small Indian village, where a band of Ojibways spend the winter. East of this village the river flows for some distance through a rolling morainic country, some of the hills being rounded and scattered with boulders, and others elongated in the direction of the valley, and composed of stratified sand and gravel. Further east the surface is much more even, and is underlaid by a fine white silt, resting on the glacial till. The woods are chiefly poplar and willow scrub.

Sandy plain. The country maintains much the same character to about the middle of range 22, where a trail branches off to the south. Here a sandy plain commences and extends to the eastern side of the same range, a few oaks being scattered over it here and there. At the above-mentioned trail the river flows in a valley eighty feet deep and half a mile wide. Land slides characterize its northern slopes which are covered with vegetation, while the south side rises in open gravel

Gravel ridge. terraces fifteen and thirty feet above the river. Near the eastern side of the above range two low gravel ridges are crossed at elevations of 1,280 and 1,260 feet above the sea, respectively, and near the western side of range 21 a strongly-marked gravel ridge is crossed at an elevation of 1,220 feet. The river here flows in a beautiful valley sixty-five feet deep, and near the bottom of the north bank is a spring of clear, cold water, smelling and tasting strongly of sulphuretted hydrogen.

About the middle of the same range the river cuts through a heavy gravel ridge on which a cart trail starts northward to Pine Creek Indian reserve, and still further east in the same range are two other ridges, the lowest of which has an elevation of 1,075 feet above the sea. Near this latter ridge is an old ford, and here the river is seventy-five

feet wide, flowing in an irregular valley a quarter of a mile wide and from thirty-five to fifty feet deep, with wide gravel flats on each side of the stream. A mile below this the banks are low, and covered with grass or timber.

Near its mouth the river flows through an open grassy plain in a channel about forty yards wide and from three to six feet deep, and empties into the lake over a bar of sand at the end of a long alluvial point.

MOSSY RIVER.

Lake Dauphin is discharged northward into Lake Winnipegosis by Mossy River, a beautiful winding stream twenty-two miles and a half long, from 150 to 200 feet wide, with an average depth of from two to four feet, and an estimated fall in its whole length of thirty-two feet.

It empties into the latter lake through low meadow land, which, in Point of June, 1889, was two feet above the water, but is evidently often flooded. This meadow is about a quarter of a mile wide, and behind it on either side is a forest of aspen. An old trading post of the Hudson's Bay Company is situated on the east bank of the stream, three-quarters of a mile above its mouth, on a narrow strip of grassy land between the forest and the river. A mile above its mouth, in a direct line, the old Government location of the Canadian Pacific Railway crosses the Crossing of stream, and near it are three exposures of Devonian limestone, the old C.P.R. upper one forming a low cliff on the west bank. Above this cliff no rock in place is seen on the river.

Two miles and a half above the Canadian Pacific Railway location there are some small islands in the middle of the stream, and between them the channels are filled with boulders, causing rapids Boulders. with a fall of two to three feet. Throughout the distance to here the river is from 100 to 150 feet wide, with an average depth of four feet and a current of a mile an hour. It has no valley, except the channel in which it flows, and which it fills from side to side. Few bars of sand or gravel obstruct its bed, but boulders of gneiss and irregular fragments of white limestone are scattered along its banks. In places the boulders stretch across the river and form ugly rapids. As the water is generally muddy, these pebbles and boulders are coated with mud.

The bank is from ten to eighteen feet in height, fringed with grass and sedge close to the edge of the water, above which is a row of small willows, and on the level land on either side is a forest of white poplar, in which there are a few trees of ash and oak. On the west side much of the forest has been burned, and there are a few open

or thinly wooded spots by the river, while on the east side the bush is mostly green, with trees from six to eight inches in diameter.

For the next two miles in a direct line the river is crooked, and is obstructed in four places by accumulations of boulders of gneiss and limestone which have fallen from the banks of loose light gray till. The Banks of till. banks are from eight to ten feet in height, the eastern one wooded as before, while on the west the river cuts into a long strip of open prairie, along which is an old cart trail to the Lake Winnipegosis salt springs. This bank is cut by several runnels, in one of which water was standing distinctly impregnated with salt. This level plain is underlaid by stratified alluvial sand or silt.

For most of the rest of the way to Fork River the stream flows by the side of this alluvial plain in a moderately straight course almost unobstructed by boulders or sand bars. It has a very easy current of from half to three-quarters of a mile an hour, is 150 feet wide and from three to four feet deep. The banks are from twelve to eighteen feet high, and composed chiefly of a loose light gray unstratified clay, often holding bands of well striated pebbles.

Fork River. Fork River empties into the west side of Mossy River at a total distance of fourteen miles and a half from Lake Winnipegosis following the windings of the stream. At its mouth it is thirteen yards wide, and flows with a depth of an inch or two over a shallow bar of gravel. The water is dark brown. For half a mile above this the brook is about two feet deep, without current, and is choked with *Algæ*, *Charæ* and water lillies. At this distance the channel is blocked by large boulders of gneiss, between which the water flows in tiny streams. This channel winds from side to side of a well-defined valley twenty feet deep, with rather extensive *intervales* wooded with poplar. North of this brook is a grove of poplar, oak, ash and maple, near which is a favourite Indian camping ground. For about seventeen miles westward across the almost level country this stream was not followed, but it was again crossed, and traced for several miles, in the vicinity of the main gravel ridge on which the trail runs northward to Pine Creek.

Fishing River. From Fork River to Fishing River, a distance of five miles along the winding channel, Mossy River is often obstructed by boulders of gneiss, and the banks are almost everywhere clothed with vegetation, most of which is poplar from three to eight inches in diameter.

Fishing River is a small sluggish brook flowing into Mossy River from the west. At its mouth it is forty feet wide, and without perceptible current. Ascending it for three-quarters of a mile, its width diminishes to twenty feet, and its depth to fifteen inches. Its bed is sandy, and its banks are fifteen feet high, and are wooded with poplar and oak.

Three miles from Fishing River, Mossy River flows from the north- Head of west end of Lake Dauphin opposite some small boulder islands. river. Throughout this distance its banks are from eight to twelve feet high, sloping and wooded, and in many places a swift current flows over a bed of sand, clay and boulders.

SWAN LAKE AND SHOAL RIVER.

Swan Lake lies seven miles south of Dawson Bay, into which it dis- Position and charges through Shoal River. It is situated in a somewhat more undulating district than Lake Dauphin, the surrounding country being, as a rule, generally immediately underlaid by glacial till. It has a greatest length of twenty miles, a greatest breadth of eight miles, a shore line of seventy miles, and an area of 121 square miles. It contains nine Altitude. small wooded islands, with a total shore line of fourteen miles and an area of one and a half square miles. The mean depth of the water is only five feet, and the greatest depth found in 1887 six feet. The bottom is soft and muddy. Its altitude, estimated from the fall of Shoal River, is twenty-seven feet above Lake Winnipegos, or 855 feet above the sea. The writer was informed by Antoine Chenaye, a native half-breed, that about twenty years previous to 1889 the lake was at its highest stage, about six feet above its present level and that Shoal River then overflowed its banks. Some years previous to that date the lake was at its lowest level, when during the prevalence of a north wind Shoal River was dry at its head, and some of the men living in the vicinity used to race horses on the dry bed of a small lake near the mouth of Swan River.

The east shore is generally a gravel beach, fringed with rushes at East shore. the bottoms of the bays, while the numerous points are surrounded by a sloping wall of boulders four to six feet in height. The boulders are chiefly of dark gray or reddish gneiss, while some are of limestone. The land rises very gently from the lake, and is wooded with poplar, with a forest of spruce in the distance.

At its south end the lake is very shallow, with a bottom of soft mud, South shore. so that it is difficult to get a canoe to the dry land. Back of this muddy beach is a ridge of rounded gravel six feet in height, wooded with elm, behind which the country descends slightly, and is wooded with balsam-poplar, spruce and balsam-fir. A spring of brine is bubbling up at one place on this low beach, in which the water gave a reading of 16° on the percentage salometer. Close to this spring a bridle trail to Pine Creek enters the woods, and runs for a mile and a quarter across low land much obstructed by windfalls, and then ascends a hill with a Kettle Hill.

total height, as determined by the aneroid, of 274 feet above the lake. On its face are six distinct terraces, the brows of which are 75, 113, 151, 170, 198 and 236 feet above the lake, the highest one rising in a long slope to the summit. The highest slope up to 236 feet is very steep, and appears to consist of sand and pebbles, while a great number of boulders of gneiss and limestone are scattered on the brow of this terrace.

Sand.

The summit is composed almost entirely of reddish sand, underlaid by rounded pebbles, with boulders of gneiss, limestone and white Dakota sandstone scattered here and there. The surface, which is slightly irregular, is thinly wooded with small Banksian pines and a few oaks. Towards the north-east the terraces are wider and more distinct than on the line of the trail. They are generally sandy and sparsely wooded, and on one of the higher terraces, at an elevation of about 200 feet above the lake, are many bare, rounded or hemispherical masses of white Dakota sandstone, from eight to twelve feet in height, with their planes of stratification horizontal, and apparently lying where they were eroded out of the soft sandstone of the base of the Cretaceous. They show no signs of glacial action, and have clearly been formed in post-glacial times, when the waves of Lake Agassiz cut this terrace in the face of the pre-existing slope.

Dakota sand-stone.

Drumlins.

Glacial grooves.

Shoal River House.

Shoal River.

The west shore is broken by long alluvial points, at the end of the most prominent of which Swan River empties into the lake. The islands off this point, near the centre of the lake, are ridges of boulders lying approximately in the direction of the glacial striation, wooded with groves of elm and maple, while the islands in the north end of the lake are composed of cream-coloured Devonian limestone polished and grooved by glacial action. These glacial grooves have a very persistent bearing S. 50° W., and the direction of the motion of the glacier is clearly shown by the fact that the hummocks are evenly rounded towards the north-east, and ragged and broken towards the south-west.

Near the north-east angle of the lake, Shoal River House, a trading post of the Hudson's Bay Company, is beautifully situated on a small open plain close to the shore, with a gently sloping beach of gravel, extending to the edge of the water. In the open clearing the land rises gently to a total height of twenty feet above the lake, beyond which is a forest of spruce and poplar. The trail from the post to the mouth of the river is cut through this forest, and at a distance of a mile and a half ascends to a height of sixty feet above the lake on a ridge of sand and gravel wooded with Banksian pine.

Shoal River flows out of the north-east angle of the lake over a low ridge of till, is nearly ten miles long, and has an average width of from



SAUBER PHOTOGRAPH

D. B. Dowling, Photo., Sept. 3, 1889.

ROUNDED BOSSES OF DAKOTA SANDSTONE
ON A TERRACE 1053 FT. A.T. ON THE NORTH SIDE OF KETTLE HILL, MANITOBA. LAT. N. 32° 21' 30"; LONG. W. 100° 37'.

150 to 200 feet. The channel is generally not more than from six to ten feet in depth; the banks are sloping, and wooded with poplar and spruce, except on some open saline tracts, while the bed is often strewn with boulders, which are collected in places and form disagreeable rapids.

RED DEER LAKE AND RIVER.

Red Deer Lake is a more or less rectangular sheet of water lying in Position and the midst of a level alluvial plain north of Porcupine Mountain and extent. west of Dawson Bay. It is thirteen miles long and nine miles and a half wide, has a shore line of fifty-one miles, and an area of one hundred square miles. It has a mean depth of five feet with a bottom of soft mud. Its altitude, estimated from the fall of the river, is forty-seven feet above Lake Winnipegosis, or 875 feet above the sea.

The south shore was examined by the writer in 1889, while the others Shores. were surveyed by Mr. Dowling in the previous year. All are low, and except at one point on the south side no rock is to be seen. This latter side is fairly straight, and the beach in the bays is composed of sand and pebbles, while on the points it consists entirely of rounded boulders of gneiss and limestone, closely laid in an even slope, which rises at an angle of 10° to 12° from the water to edge of the spruce and poplar forest.

The Red Deer River empties into the west side of the lake at the Red Deer end of a long alluvial point, and again flows from its south-east corner River. eastward towards Lake Winnipegosis. From its head, where the water is very shallow, to the mouth of Rice Creek, the river is wide, with a swift current, and boulders of gneiss form bars out into the stream.

Rice Creek, called by the Indians Manomina Sipi, was ascended Rice Creek. in a canoe for a mile and a half to a light rapid where the water flows over loose slabs of white limestone. It is a small creek from twenty to twenty-five feet wide, generally with a soft bottom, and occasionally almost blocked with grass. The country on both sides is low, level, and often saline, and the banks are overhung with willows. From the little rapid an open wet meadow extends southward for a couple of miles to a forest of spruce. The creek appears to flow down the face of the mountain in a narrow gorge, on the sides of which are some bare white cliffs, which appear very conspicuous from the islands and shores of Dawson Bay.

From the mouth of Rice Creek to the head of the Long Rapid, Long Rapid. where a band of limestone crosses the stream, the river fills the channel from bank to bank, and with the exception of one slight rapid, flows

with an even current and is moderately deep. The banks are low, and wooded with poplar and a few spruce. The limestone shows strong glacial grooves striking S. 75° W., or directly across the river. In the rapid, which is about a mile in length, the river is shallow, and filled with large granite boulders, while several wooded islands break up the channel. On the south bank, opposite these islands, is a watercourse coming from a wide saline area scattered with pebbles and boulders, and dotted with groves of poplar. Several springs of brine are rising in this flat, but all were so shallow and muddy that it was impracticable to test them with the salometer. A small stream of brine was flowing about five gallons a minute in the bottom of the watercourse.

Upper Salt Spring.

Glacial striæ.

At the bottom of the rapid the river bends sharply towards the north-east, and is moderately deep for a mile and a half to a hill which rises on the north bank to a height of twenty feet, on the south side of which are some brine springs at which the Indians occasionally boil down the water to obtain a small quantity of salt. The hill is composed of limestone, and its north-east side, which is bare in places, shows indistinct glacial striæ trending S. 65° W., and on the south-east side is a little patch about three feet square of a light, reddish till holding rounded pebbles and cobbles of gneiss and limestone. The face of the hill, down which the brine is trickling, is covered with fragments of limestone, among which were many beautifully preserved fossils. A mile below this hill, which has been called the "Upper Salt Spring," a small salty creek, carrying about four gallons of water a minute, flows in from an open area towards the south.

From this creek downwards to the lowest Salt Spring the river is one continuous rapid, flowing in a winding course through boulders, having a bare gravel beach on each side.

A short distance below the briny creek, and still on the south side, is a slightly elevated mound, from the centre of which is issuing a spring of brine flowing about ten gallons a minute. It has a temperature of 42° F., and gave a reading of 22° on the salometer.

At the bend below is a cliff of limestone, the summit of which is polished and scored with grooves running S. 80° W. Above the limestone is a hard, light gray clay, containing striated pebbles and boulders. Just below this cliff is a small salty brook flowing five gallons a minute, and in which the salometer gave a reading of 22° .

Higher banks.

From this point the banks ascend to a height of twenty feet, and consist in many places of cliffs of limestone overlaid by till filled with pebbles and boulders, most of which are granite or local rock, while some are Niagara limestone, containing *Pentamerus decussatus*. The lowest cliff of limestone on the river is also overlaid by till, and the

surface of the rock below the till is beautifully polished and striated in a direction S. 80° W.

The Lower Salt Springs occupy an open area of about 100 yards square on the north side of the river and twelve feet above it. The area is strewn with eroded boulders of gneiss and limestone, and small springs of brine bubble up every here and there, in one of which the brine seemed to be very concentrated, giving a reading on the salometer of 75 per cent.

Below these springs the banks are low and alluvial, and there is but little current in the river.

CEDAR LAKE AND SASKATCHEWAN RIVER.

Cedar Lake is an irregular body of water lying in the extreme Position. northern part of the area included in the map, and is separated from Lake Winnipegos by a narrow belt of high land from four to five miles in width, which cuts across what would otherwise appear to be a single natural basin. Its greatest length is thirty miles, its greatest width is Extent. fourteen miles, it has a shore line, within the map, of 108 miles, and an area of 330 square miles. Its depth is from thirty to forty feet, and its elevation above the sea 828 feet, both these measurements being the same as those for Lake Winnipegos.

At its western end the lake receives the waters of the Saskatchewan River in the middle of a little archipelago of small rocky islands. On the outermost and largest of these islands the early French traders are stated to have had a fort. This fort or trading post, which was called Fort Bourbon, was founded by one of the sons of Sieur de la Verendrye Old Fort in 1741. He reached the site by travelling northward from Fort la Bourbon. Reine (Portage la Prairie) across lakes Manitoba and Winnipegos. The island is thickly wooded with spruce. At its north end is a low cliff of limestone with a gravel spit projecting beyond it, behind which is a pleasant harbour for small boats. At its south end is a rounded hook of gravel inclosing a shallow bay.

From the mouth of the Saskatchewan southward the shore of the lake is low, with a more or less sandy beach, behind which is a level spruce and tamarack swamp. With the sand and debris on the beach are scattered many particles of fossil resin that have been washed down Fossil resin. by the Saskatchewan River from the Cretaceous shales and sandstones higher up the stream. The south shore is without prominent cliffs, and consists of stretches of even sandy beach between salient points piled high with large boulders of gneiss.

Rabbit Point. Rabbit Point is a low, sandy promontory on the north shore, invested with a mournful interest, as here lie the remains of Benjamin Frobisher, one of the early partners of the North-west Company. In the troublous times just before the union of the North-west and Hudson's Bay Companies he was taken prisoner by the latter and carried to York Factory, from which place he escaped in the autumn of 1820. He ascended the Nelson and Saskatchewan rivers on his way to a trading post on Moose Lake, but at Rabbit Point, worn out by hunger and fatigue, and while his Indians were absent at Moose Lake in search of relief, he expired beside his lonely bivouac fire.

Rocky Islands North-east of Rabbit Point an arm of the lake extends for twelve miles past low wooded shores and small rocky islands, where gray cliffs of limestone peep out here and there from under the covering of dark green spruce. At the end of this arm of the lake a deep, narrow channel, known as "The Narrows," runs between a small island and the south shore. Here the Saskatchewan River may be said to commence again, but its characters are entirely different from those of the sluggish stream which flows into the west side of the lake. Instead of filling, it is rapidly deepening its channel, tumbling and sliding down rocky limestone ledges in wild rapids, between which are quiet stretches. One of these expands in Cross Lake into a comparatively large body of water.

Grand Rapid¹. The Grand Rapid (the last of these rapids and the most interesting feature on the Saskatchewan River) has a total fall in five miles of seventy-one feet, the most of which is concentrated into two miles in the middle of the distance. In these two miles the river has cut a deep, narrow gorge in the horizontal limestone, part of which gorge is post-glacial and part pre-glacial in age.

Tramway. To overcome the difficulty of transporting goods and boats past this rapid by hand, the Hudson's Bay Company engaged Walter Moberly to build a tramway three miles and a half in length past the rapids. This was done in 1877, and on the eleventh of September of that year Lady Dufferin, who, with Lord Dufferin, the Governor-General of Canada at that time, was travelling in the west, drove the last spike in this remote railway.

Descent of the rapid by John Fleming. The following excellent description of the descent of the Grand Rapids below the east end of the old portage is given by Mr. John Fleming :—

"In running the rapid we followed as closely as possible the instructions given to us by our old guide on the plains (John Spence) who had often piloted the old N. W. Co.'s *north* canoes down its entire length. In attempting, according to his directions, to cross

from the north to the south side of the rapid in order to get into what was reported to be the best channel for a small canoe, such was the fierceness of the current and the turbulence of the great surges and breakers in the middle that we were nearly engulfed; and although every nerve was strained, we were swept down with impetuous velocity, and did not get near the other side till we were about three-quarters of a mile below our starting point. We were then impelled with astonishing swiftness along the south side of the torrent, often in dangerous proximity to the rugged wall of rocks bounding the channel, and now and then whizzing past—almost grazing—sharp rocky points jutting out into the river, against which the thundering waters seethed and foamed in their fury. During the descent the voyageurs exerted themselves to the utmost of their strength, and evinced an admirable degree of coolness and dexterity.

"The Grand Rapid is acknowledged by those who have witnessed it, and who have had opportunities of traversing the great river systems of the continent, to be unsurpassed in magnificence and extent, as well as in volume of water."*

PHYSICAL GEOGRAPHY AND GEOLOGY

COUNTRY WEST OF THE LAKES.

This region is entirely underlaid by the soft and easily-eroded Cretaceous shales and sandstones, which are lying in an undisturbed and almost horizontal attitude. The streams are small, and in many cases are not now actively eroding their channels, and old escarpments soon crumble down to easy slopes and become overgrown with vegetation, so that good natural exposures are infrequent. Very often the lines bounding the different formations have therefore necessarily been drawn on hypsometrical evidence. It has consequently been found inadvisable at present to separate the description of the geography from that of the older geology of this district.

For the sake of greater accuracy, the river valleys and trails followed will be described in succession, beginning with those in the south-eastern portion of the district.

The Ochre River rises on the summit of the Riding Mountain and Ochre River, flows in a general direction N. 25° E. for twenty-five miles to its mouth at the southern extremity of Dauphin Lake. In the upper part of its course it flows in a wide and gradually deepening depression, in the

*Report of the Assin. and Sask. Expl. Expedition by H. Y. Hind, Toronto, 1859, p. 78.

High hills.

bottom of which it has cut its own distinctive valley. Where it crosses the line between ranges seventeen and eighteen, the valley is seventy feet deep, the banks are composed of light gray unstratified boulder-clay, and the bed of the stream consists of rounded pebbles of limestone, &c., with a few rounded fragments of rather hard light gray clay shale. Beyond, the hills rise both to the east and to the west to a height of about 700 feet. In most cases these hills are thickly wooded with spruce and poplar, but there are a few steep, naked banks, apparently of the light gray clay shale, that everywhere constitutes the topmost Cretaceous beds on this mountain. It was to the top of the hill west of this valley that Prof. H. Y. Hind climbed in his trip from Dauphin Lake to Riding Mountains in October, 1858.

Pierre shales.

Following the river downwards from the crossing of the above line, which is at an elevation of 1,250 feet above the sea, the bed of the stream soon becomes very much obstructed by large boulders of gneiss and limestone, many of the latter of which are striated. In the bank, croppings of dark gray soft clay shale begin to make their appearance from under the overlying till, and soon become conspicuous in all the scarped banks at the convex bends of the stream. A mile south of the Correction Line a bore-hole was sunk to a depth of 150 feet. The rock is a soft, unctuous dark clay shale, showing in many places an efflorescence of sulphate of iron, and often containing between its layers thin sheets of small crystal aggregates of selenite. A hard band of limestone runs along close to the edge of the water. Mr. A. McDonald, who sank the above mentioned bore-hole, informed me that with the exception of a 2-inch seam of coal, which was passed through at a depth of forty-four feet, the whole 150 feet was sunk in dark gray clay shale similar to that seen at the surface.

Bore hole.

For two miles and a half below this point, or for one mile and a half below the seventh Correction Line, similar shale is seen in the banks of the river. Close to the crossing of the Correction Line a ridge crosses the river, which in ascending section shows twenty-five feet of dark gray clay shale overlaid by fifteen feet of rounded pebbles and boulders bedded in a sandy matrix. The ridge is 450 feet wide, slightly rounded on top, and rises sharply for forty feet from low land of about the same height on both sides. The course of the ridge is N. 88° E. It is thickly overgrown with poplar mixed with some oak, maple (*A. spicatum*) and elm, while birch, ash-leaved maple and spruce are growing on the adjoining low lands. Beneath this heavier timber there is a thick growth of Amelanchier and Pembina bushes. There are other ridges both above and below this one, on one of the former of which is an Indian trail leading to the south, but this one is the most clearly defined of any that cross this river.

High gravel ridge.

Just above this ridge a number of fossils were collected from the Fossils, dark shale and an included band of limestone, consisting of *foraminifera*, oysters, Inocerami and fragments of plates of fishes.

For a mile and a half below this ridge similar soft dark clay shale crops out at intervals, including in one place a bed of hard sandstone holding numerous remains of small oysters.

The whole of the Cretaceous beds seen on this river appear to be Cretaceous beds. lying almost or quite horizontal, the total thickness seen from the first outcrop below the line between ranges 17 and 18 down to the last outcrop seen on the river being about 175 feet.

Before reaching the above-mentioned lowest outcrop of dark shales, Winding channel the hills on either side have fallen away, and the river has left the Riding Mountain and now flows across the lacustrine plain at its foot towards Dauphin Lake. Its channel becomes ten to forty feet deep, forty feet wide and very crooked, the wide gravel flats and bars seen higher up the stream having here almost entirely disappeared. The banks show neither the underlying shale, nor till, but are composed entirely of stratified clay often mixed with a considerable quantity of sand.

The channel is usually skirted with a dense belt of trees, such as cottonwood, balsam-poplar, elm, &c., behind which are many beautiful meadows sprinkled over and separated by groves of aspen and willow.

Edwards's Creek rises in the Riding Mountain a short distance south of the 7th Correction Line, and flowing parallel with the last-named stream, joins the Vermilion River a few miles above its mouth.

At the crossing of the Correction Line the valley is only forty feet deep, and the bed is at an elevation of 1,820 feet above tide. The valley, however, rapidly deepens, soon becoming a narrow gorge 160 feet Deep gorge. deep with very precipitous scarped banks of horizontal light gray shale, often appearing red from iron stains.

Three-quarters of a mile below the Correction Line and just below the entrance of a small stream of slightly greater size from the east, there is a steep bank on the east side showing an exposure 160 feet in High cliff of Odanah shale. height. The upper thirty feet consists of sandy boulder clay or till containing small pebbles, most of which are of limestone, but some are of granite. Below this is 130 feet of slaty light gray clay shale, much jointed and generally showing iron stains on the jointage faces. A quarter of a mile down the stream, but at thirty-five feet lower level, and at an elevation of 1,720 feet, this light lead-grey slaty shale is seen to be underlaid perfectly evenly and conformably by fifteen feet of dark grey Millwood shale. The difference between the two shales is quite clearly marked, especially as the lower shale weathers out into irregular

rhombic particles, while the upper weathers into thin flakes. For a mile and a half below this the banks of the valley consist largely of irregular slides of the overlying slaty shale, but in several places near the river a soft dark gray clay shale was seen, crumbling into clay, precisely like the Pierre shales of the Bow River and Upper Saskatchewan. Near the lower end of the above distance this shale includes a band of lenticular nodules of clay ironstone. This is at an elevation of 1,500 feet above the sea.

Boulders.

For the next three miles down the river, or to the mouth of a small spring brook coming from the east, no exposures of the Cretaceous rocks were seen. The channel is at first very much blocked by Archaean boulders, and fragments of ironstone as large as cobble-stones are quite numerous, but soon the boulders disappear and the bed of the stream Odanah shale. is composed of pebbles of Odanah shale, with some of quartzite and gneiss and a few of ironstone. The banks, too, are at first composed largely of pebbles of light gray slaty shale, but this soon changes to stratified sand overlying unstratified till, and the stratified sand again to stratified clay.

Gravel ridge.

Half a mile above the mouth of the spring brook a gravel ridge twenty-five feet high crosses the course of the stream, composed, to the bottom, of stratified sand and gravel. The gravel consists almost entirely of smooth lenticular pebbles of lead-grey clay shale, mixed with a few small pieces of ironstone, and pebbles of quartz and gneiss as large as marbles.

Niobrara shale.

At the mouth of the spring brook, at an elevation of 1,271 feet above tide, a dark gray clay shale, mottled with small particles of calcareous material, makes its appearance, and the valley becomes rapidly deeper and the bed of the stream is filled with large gneissoid boulders.

Foraminifera.

Three-quarters of a mile below the mouth of the creek a bed of rather hard, gray, argillaceous limestone, containing *Inocerami*, crops out four feet above the bed of the creek, overlaid by fifteen feet of dark gray mottled clay shale, and this is again overlaid by a bed of unstratified till holding large gneissoid boulders. Three-quarters of a mile further down, where the river crosses the southern line of township 24, the valley is fifty feet deep, the lower thirty-five feet of the bank consisting of dark gray mottled clay shale, the top of which consists of a bed one to two feet in thickness of white or light yellow chalky limestone, containing numerous fragments of *Inocerami* and scales of fishes similar to those found on Ochre River, as well as numbers of foraminifera belonging to the genera *Textularia*, *Rotalia*, &c. This is the same band as the one mentioned in the last exposure, but it has become less argillaceous and much softer and more chalky. When struck, it emits a slight odour of petroleum.

It is directly overlaid by eight feet of rounded gravel, mostly of limestone and shale, but mixed with pebbles of quartzite and gneiss. This gravel is moderately fine throughout, but much the finest near the surface. Ascending the bank, this escarpment is seen to be the section of a gravel ridge extending across the country parallel to the face of the mountain and rising in easily rounded slopes ten feet above the country on either side. On going a little further north a steep slope is encountered, descending abruptly for fifty feet, and the above ridge runs parallel with this slope and about 300 yards back from its brow.

From the foot of this slope the country descends gently to Lake Dauphin, being either open meadow land, scattered poplar coppice, or swamp.

Vermilion River rises near the summit of Riding Mountain in several small streams which flow together either in, or near, the foot of the mountain. The branch followed rises a short distance north of Lake Audet and flows northward for ten miles till it is joined by a similar stream from the west, and throughout this distance the waggon trail to the Lake Dauphin settlement follows its eastern side, at first through groves of poplar separated by prairie openings, and then through thick though not very heavy timber, consisting of aspen and balsam poplar, with some spruce, tamarack and small birch. Five miles south of the fifth Correction Line a small stream joins the Vermilion River from the east, flowing in a narrow gorge-like valley. At the point where the trail crosses this valley it is ninety feet deep, and the elevation of the bed of the stream is 1,750 feet above tide. Just above the crossing there are several small crumbling exposures of light lead-gray fissile Odanah shale, similar to the upper beds on Edwards's Creek ; and two miles farther down the main stream, similar shale again crops out. At the trail crossing, a short distance above the forks, the stream is twelve feet wide, and when crossed in July, 1887, was six inches deep, with banks consisting of pebbles of gneiss and limestone.

Two miles and a half below the forks, on the south side of the river, there is a cut bank ninety feet high, consisting at the top of twenty feet of dark gray friable clay shale holding bands of nodules of white or light gray limestone very much veined with calcite, and weathering down into a white powder, while below it, is seventy feet of dark slate-gray clay shale, emitting, when struck, a strongly bituminous odour. At the bottom, these beds contain numerous acicular crystals of selenite. A mile ^{High cut banks.} Trail crossing. below this point the trail crosses the river at an altitude of 1,310 feet ; 300 yards above the crossing is a high cut bank of horizontal slate-gray clay shale, mostly very friable and holding many small crystals of selenite. In the bank were some thin bands of ironstone and large

Fossils.

nodules coated with a layer of calcite, which has the appearance of being the partly decomposed shell of *Inoceramus*. A fragment of a Baculite was also found. About a mile south of the crossing, a high hill rises 325 feet above the level of the river at this point, or to a height of 1,635 feet above the sea. On the top of it may be seen small irregular outcrops of soft crumbling light gray shale, with bands of nodular clay ironstone a short distance below the summit. Fifty feet below the summit a considerable thickness of this shale is exposed lying quite horizontally.

At the crossing several low outcrops of shale are exposed close above the edge of the water. It is here very tenacious, has a greasy feel, cuts like cheese, and emits a strong bituminous odour.

Boring on Vermillion River.

A well was bored near this point by the Manitoba Oil Company to a depth of 743 feet, in the hope of obtaining petroleum. The following is the report of this well as published by the writer in the *Trans. Roy. Soc. Can.*, Vol. ix., Sec. iv., pp. 102-104.

"Boring on Vermilion River."

Position.

This boring was sunk by the Manitoba Oil Company on the west bank of the Vermilion River, a short distance below the crossing of the Strathclair and Lake Dauphin trail, in Township 23, Range 20, west of the Principal Meridian.

Date.

In the spring of 1887 a percussion drill was hauled north from Strathclair station, on the Manitoba and North-western Railway, and the well was drilled to a depth of 292 feet, when an accident happened to the machinery which delayed the work for a time.

In the following year the drill was moved a short distance down the valley, work was resumed, and a final depth of 743 feet was reached.

From a comparison of the sections, the second well is found to have been begun nine feet lower, geologically, than the first, and therefore the levels of all the specimens obtained from it have been corrected by the uniform subtraction of nine feet, in order to give them their proper position in the total section.

For the log of this well, with illustrative specimens, I am indebted to the kindness of W. R. Baker, Esq., Superintendent of the Manitoba and North-western Railway, who was one of those most deeply interested in the success of the well.

The record as given below is compiled from the log kept by the driller and the results of my examination of the specimens.

HEIGHT OF SURFACE AT BORING ABOVE SEA, 1,300 FEET.

Synopsis of record.

Number.	Description of Material passed through.	Thickness of layer in feet.	Depth of bottom of layer from surface.	Height above sea.	Remarks.
1	Soft, dark gray clay shale.	95	95	1,205	Pierre (Millwood series).
2	Fragmental limestone	4	99	1,201	} Niobrara.
3	Gray calcareous shale	124	223	1,077	
4	Dark gray fissile shale.	178	401	899	Benton.
5	Coarse sandstone, with pyrites.	19	420	880	Dakota.
6	Compact white limestone.	120	540	760	
7	Blue-gray clay shale.	10	550	750	
8	White gypsum.	15	565	735	} Devonian.
9	Red shale.	110	675	625	
10	Shale and limestone.	68	743	557	
11	Red shale.	At bottom.			

No. 1.—Specimens from 30, 48 and 91 feet show this to be a soft, Pierre shales, dark gray, non-calcareous clay shale belonging to the Millwood series of the Pierre shales, similar to that seen in the naked and almost vertical cliffs washed by the river a few hundred yards above the trail crossing.

No. 2.—This is a hard band that was spoken of as "sandstone" by the driller. It consists almost entirely of fragments of the prisms of the shells of a large *Inoceramus*, mixed with fragments of *Ostrea congesta*? This evidently represents the band of sandstone-like limestone that outcrops on the Assiniboine River below the mouth of Cypress Creek, and is also seen at several places along the eastern face of the Riding Mountain. It lies at the top of the Niobrara formation.

No. 3.—Specimens collected from 146 and 164 feet show this to be a mottled, blue-grey, calcareous clay shale or marl. Under the microscope it is found to be mixed with prisms of the shells of *Inoceramus*, fragments of the shells of *Ostrea congesta*?, minute portions of fish skeletons and quite a large number of foraminifera. These comprise such forms as *Globigerina cretacea* and several species of *Textularia*, and with them are associated many *Coccoliths* and *Rhabdoliths*. These evidently represent the characteristic shales and marls of the Niobrara formation.

No. 4.—Specimens obtained from 213—247 feet consist of a dark Benton shales, blue-gray, fine-grained, unctuous, non-calcareous clay shale, breaking down into thin flakes. These represent the typical Benton shales.

No. 5.—A specimen from 411 feet consists of grains, varying greatly in size, of clear, white quartz. Some of these grains are quite angular

Dakota sandstone.

in shape, and many are stained on the outside with iron. With the sand grains are mixed small cubical crystals of pyrite. In a paper published in "The American Journal of Science" for September, 1890, the writer gave the Dakota formation in this well a thickness of 55 feet, but he has since found reason to believe that a specimen of sandstone labelled 369 feet is not to be depended on, and the record has therefore been altered as above to agree with the log kept by the driller, thus reducing the thickness of the Dakota to 19 feet.

Devonian
limestone.

No. 6.—A specimen from 509 feet is a moderately hard, fine and evenly-grained, light gray limestone, through which are scattered small subangular grains of colourless quartz and grains of pyrite. A specimen marked 510–540 feet consists of similar limestone, with fragments of light and dark gray clay shale.

Shale.

No. 7.—A specimen from the lower part of the band consists of a mixture of light blue-gray clay shale, particles of limestone, some few crystals of colourless quartz, and particles of opaque white gypsum from the top of the band below.

Gypsum.

No. 8.—A specimen marked 550–565 feet is made up largely of fragments of opaque white gypsum, mixed with a few fragments of colourless quartz, and small nodular masses of pyrite.

Shale.

No. 9.—A specimen marked 565–645 feet consists of a soft, light brownish-red, fine-grained shale, mixed with fragments of light gray shale and particles of limestone. In the clayey mass are also many minute and very perfect crystals, as well as irregular particles of clear transparent quartz.

Shale and
limestone.

No. 10.—A specimen from 718 feet consists of a light pink, hard, compact, fine-grained limestone that effervesces strongly in HCl., leaving a similarly coloured fine clayey precipitate. With the limestone are many fragments of a fine-grained, white sandstone, and a very few white, opaque particles of gypsum. A specimen from 740 feet is a mixture of fragments of cream-coloured limestone and reddish shale. It effervesces strongly in HCl., leaving a residue of dark gray and buff-coloured shale, fine grains of quartz and small particles of pyrite.

Absence of
fossils.

No fossils have been obtained from the Palaeozoic rocks drilled through in this well, and in the absence of direct stratigraphical correlation their exact age cannot at present be determined. However, their geographical position clearly shows that they are of post-Silurian age, and the absence of dolomites excludes them from the middle or Winnipegosan formation of the Devonian. It is also altogether unlikely that fossils would have been so uniformly absent from the drillings if some of the lower highly fossiliferous beds of the Manitoban, or Upper Devonian formation had been passed through. Many of the

limestone fragments from near the bottom of the bore correspond closely with the limestone outcropping near the mouth of Mossy River, at Point Wilkins, etc., belonging to the higher portions of the Manitoban formation exposed in natural sections, and the known southwesterly dip of a few feet to the mile would account for the difference in elevation of the beds.

It is therefore probable that the Palaeozoic beds passed through in Upper Devonian. the Vermilion River boring represent an upward continuation of the Point Wilkins limestones, and therefore in the main, overlie the highest Devonian beds seen on the shores of Swan Lake or Lake Winnipegosis."

Following the valley of the river for three miles below the trail crossing, the banks are high, and generally consist of soft dark gray Cretaceous shale, though in places unstratified till composes the greater part, or even the whole, of the cliff. At one of the latter places the scarped bank consisted of forty feet of light yellowish-gray till, in the top of which was imbedded a layer of large transported boulders, overlaid by twelve feet of yellowish-gray stratified sandy clay without boulders. At the end of the three miles, and at an elevation eighty feet lower than the river at the crossing, the bank is composed of similar dark gray soft shale, while at the edge of the water a bed four feet in thickness of hard sandy limestone crops out, holding remains of oysters and Inocerami. As the river is followed down still further this limestone band gradually ascends in the banks, till at the end of a mile it is seventy-five feet up the bank, and is underlaid by mottled gray shale through which are scattered fragments of Inocerami and remains of fishes. In Four Mile Creek, which is a small stream flowing in from the east half a mile below the last mentioned exposure, this hard band is seen ninety feet above the level of the river at its mouth. Fifty feet below this band of hard limestone there is a band of rather hard light grey shale, and as the river is descended this band becomes better defined, till at the outer, steep slope of the mountain it is a band of rather hard white limestone crossing the face of the escarpment at a height of ninety feet above the river. This band of white limestone contains many Foraminifera of the genus *Textularia* with great numbers of *Coccoliths*. For one-third of a mile below the edge of the escarpment similar mottled shale crops out, but the banks have now become low and often swampy. At this point Mr. Arch. McDonald sank a bore hole 120 feet, and found similar shale to the bottom, and the same man informed me that similar shale crops out in low exposures for a mile further down the creek, beyond which nothing is seen but drift and alluvium. Three miles further down, where the river was again seen, the banks consist for several miles entirely of bedded clay. The Vermilion River below the trail. Limestone.

river flows in a narrow winding channel, has a muddy bed, often scattered with pebbles, and belts of timber skirt its sides, beyond which the country is generally open, grassy meadow land.

Wilson River. Wilson River rises on the north-east side of the Riding Mountains and flowing eastward, falls into Dauphin Lake a short distance north of the mouth of Vermilion River. Where first seen in township 25, range 22, the banks are twenty feet high, with steep grassy slopes to the edge of the water. The elevation at this point is 1,300 feet above the sea. Following the stream eastward the valley gradually deepens till the banks are about 100 feet high, and then it again becomes shallow and like the other rivers in the district flows in a winding channel through almost level partly wooded country to its mouth.

Banks of till. At the point where the river was first seen and for three miles and a half below it, the banks consist of light gray sandy unstratified clay containing numbers of irregular pebbles and boulders, but about the centre of the distance a low ridge of rounded gravel, with an elevation of 1,288 feet above the sea, crosses the valley, running in a N. N. W. and S. S. E. direction. This ridge was the highest ancient lake beach observed on this river, and west of it the country gradually rises in the low gently rounded swells and undulations typical of the western plains.

Niobrara shale.

At the lower end of the portion of the valley above mentioned, and at an approximate elevation of 1,190 feet above the sea, a light gray mottled calcareous shale of Niobrara age outcrops on the side of the bank ten feet above the river, and ten feet above it is a band of cream-coloured marl containing fragments of such fossils as *Ostrea*, sp., *Inoceramus problematicus*, an obscure fragment of an Ammonite, and great numbers of foraminifera belonging to the genera *Globigerina* and *Textularia*. The beds have a light dip S. 60° W.

Descending the river, for the next three miles the banks vary considerably in character, but everywhere the bottom is found to be composed of clay shale, sometimes very much darker than that first seen, and often containing interstratified beds of soft white unctuous clay. The beds are throughout horizontal and often contain fragments of oysters, Inocerami and scales of fishes. The exposures of shale are in some places fifty feet high and are generally overlaid by a light yellowish-gray compact till, often, especially towards the bottom, containing a great number of large boulders of gneiss and limestone.

Gravel ridge.

At the point which has now been reached, a strongly marked ridge of rounded gravel having an elevation of 1,150 feet, crosses the country in a general direction parallel to the one already passed higher up the river. This ridge is devoid of timber and thinly grassed on top.

and on it the Indians have one of their main trails into the country to the north. After cutting through it the river takes a course a little south of east and flows in a thickly wooded valley, with high banks that often show good exposures of horizontal mottled gray calcareous clay shale. Two miles east of this ridge is a cut-bank showing a very good section of fifty feet of this shale, in which, fifteen feet from the bottom, is a bed of what appears on first sight to be a light brown lamellar sandstone, but which, on closer examination, is found to be composed of minute dark brown fragments of teeth and bones of fishes, cemented together by a calcareous cement. This shale is highly phosphatic. A specimen of it was analysed by Mr. Hoffmann of this Department, and he reports that it contains 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. The extent of this phosphate bed could not be determined at the time, but if it should prove to be large, it will furnish a very valuable source of supply of phosphate of lime to renovate the wheat lands of Manitoba and the adjoining Territories. In many of its characters it approaches closely to the coprolite beds which are so extensively worked for phosphate of lime both in France and England.

For a mile below this outcrop of phosphatic shale, small naked scarps of dark gray shale occasionally overlook the river, and then the valley becomes more diffuse, and appears to assume the characters of the Vermilion and Ochre river valleys in the lower parts of their courses, with banks composed entirely of stratified alluvial sand and clay.

Valley River is stated to rise in Singoosh or Weasel Lake in the north-eastern portion of the Duck Mountains. It flows first south-westward and then southward over a drift covered region, till it emerges in the wide valley north of the Riding Mountain. It is here a beautiful clear stream thirty feet wide and two feet deep, flowing over a bed of rounded limestone pebbles. The valley which it has entered is more or less open and grassy throughout, though, of course, dotted with groves of poplar and willow, and there is here a pleasant looking little Indian village, consisting of several well-built log houses, with good, though diminutive, stables, around which a small amount of land has been tilled, and a considerable quantity of hay is annually cut. The large number of new graves on the tops of the surrounding knolls testified to the fearfully high mortality rate prevailing among these people, who are gradually diminishing in numbers, not because a sufficient number are not born into the world, but because all the ordinary laws of hygiene are so entirely neglected that only a few of the very hardiest ever reach maturity.

Morainic ridge.

From the Indian village the river flows eastward for ten miles. For the first mile the valley is generally open, with a gently rolling surface. For the next two miles the cart trail on the north side of the river winds over and among morainic hills, which appear to extend across the valley and along the face of the escarpment on either side. The hills are in the shape of rounded knolls, which may be joined together in irregular ridges, often one hundred feet high, among which are numerous little rounded freshwater ponds, without apparent outlet. The sides of these hills are covered with large gneissoid boulders and small pebbles of quartz, gneiss and limestone of very irregular shapes. Some of the latter are striated, though all are very much covered with calcareous tufa. But one geological section was seen in these hills, and it consisted of twenty feet of light brown slightly sandy calcareous clay, containing a few pebbles and small boulders. One of the latter was a lenticular nodule of ironstone, evidently derived from the Cretaceous rocks. The clay was quite unstratified and a large number of the pebbles were of limestone, almost all of which showed glacial striæ.

Near the eastern side of this hummocky ridge, a small stream flows from the north, and its bed is covered with large irregular boulders of gneiss. The altitude of the mouth of this stream, where it flows into Valley River, is about 1,362 feet.

For a mile and three-quarters below the mouth of this creek the bottom and sides of the valley are much more even, but a great many large gneissoid boulders are scattered over the flats on each side of the stream.

Kames.

Below this boulder-strewn portion of the valley, the banks diverge to a certain extent and a kame-like ridge, or series of ridges, begins and continues eastward for four miles down the middle of the valley. These ridges have a generally oval contour, with sides rising in rather steep slopes from the bottom of the valley. Their tops vary from slightly undulating, to quite rough and hummocky, and are generally more or less thickly strewn with gneissoid erratics. The most westerly of these kames is three-quarters of a mile in length and 250 paces wide on top. On its south side, where the river impinges against it, there is a naked bank showing an exposure forty feet in height, though on account of slides it was impossible to measure the different beds of which it was composed. At the top the exposure consists of rounded and water-worn pebbles and boulders of limestone, gneiss, &c. The pebbles are separated out and arranged in horizontal layers. The lower part of the bank consists of sand without pebbles.

Below these kames the river turns and flows for ten miles in a general north-easterly direction. The valley which had become very much

diffused, again becomes well defined and rather narrow. The banks Sloping banks. are sloping and either grassy or covered with small aspens, and the soil of the valley and the surrounding country is occasionally sandy, but is usually a fine clay formed from the weathering of a fine light gray or white silt that overlies the boulder clay.

Very few exposures of the underlying beds were seen, and these consist almost entirely of light gray unstratified till, containing numerous striated pebbles and boulders of limestone, &c. In some places the irregular surface of the till is overlaid by from two to three feet of fine grained yellow or gray silt with a well defined stratification, which follows closely the surface irregularities of the till.

At the end of this stretch the banks of the valley are thirty feet high, and the river is flowing over a bed of pebbles many of which are distinctly striated. Here the river takes a great sweep to the south, while the trail turns to the east and, after crossing a level plain for five miles, comes to its north bank again where another trail crosses it and running south-eastward to the Riding Mountain joins the Vermilion River trail near the forks of the latter stream. The valley of Valley River is here half a mile wide, eighty feet deep, and the stream flows over a bed of rounded water-worn pebbles and boulders. The north side is very uneven and probably much slidden, but on the south side there is a bottom land consisting of stratified sand and gravel fifteen feet above the Valley water, fifteen feet above which is a well-defined terrace of similar deposits, beyond which the bank rises to the general level, at an elevation of 1,270 feet above the sea. Vermilion River trail. Valley terraces.

From this point the river flows in a general north-easterly direction for ten miles. For the first four miles the valley is very rough and uneven and the trail keeps some distance back from it on a slightly undulating, gravelly or sandy plain, thinly covered with a sparse growth of short grass, on which are standing here and there a few stunted oaks, while to the north are seen numerous groves of small aspen. This sandy plain is an ancient delta deposit formed by the stream that here flowed into the western side of Lake Agassiz, when this large post-glacial lake stood at one of its highest stages. A quarter of a mile before the trail again touches the bank of the river a low ridge of rounded gravel is crossed, the most westerly ridge seen on this river, having an elevation above the sea of 1,290 feet. The trail reaches the bank of the river on another of these ridges of rounded gravel, its even grassy surface having been a favourite camping ground for the Indians hunting through the district. The top of this ridge, which is seventy feet above the river, is seen to be composed of stratified sand and gravel, but most of the lower portion of the face of the bank Ancient delta. Gravel ridge.

is covered with slides, so that very little of the underlying rock is seen. What is exposed, however, is a mottled gray Niobrara shale with bands of almost white chalk marl, holding fragments of *Inoceramus problematicus* and many foraminifera of the genera *Globigerina*, *Textularia*, &c. Near the foot of the bank is a spring of clear cold water tasting and smelling very strongly of sulphuretted hydrogen.

A mile and a quarter below this ridge, a small stream joins Valley River from the north, and at its mouth is an excellent exposure of six feet of horizontal, gray, mottled clay shale holding a broad form of *Inoceramus problematicus*. Below the mouth of this creek the banks again become largely composed of boulder-clay, and the underlying shale was not seen for a distance of three miles and a half, when a dark gray clay shale was seen in an exposure extending sixteen feet above the river. The boulder-clay or till which overlies this shale and forms the banks for most of the remaining distance, is, as usual, a light gray unstratified sandy clay containing numerous pebbles and boulders, most of the limestone ones of which show distinct glacial striæ. Two very distinct gravel ridges cross the river in this distance. One of them, two miles and a quarter below the mouth of the small creek, was very carefully examined. It is the same ridge that was noted as being the largest ridge on the Wilson River, and on it the Indians have their main pitching track towards the north along the eastern face of the Duck Mountains. The ridge is here being rapidly cut away by the stream, and the following descending section is distinctly shown :—

Section of
post-tertiary
deposits.

	ft. in.
Sandy and pebbly loam.....	2 3
Well stratified gravel in a matrix of light yellow quartz sand. The pebbles are mostly limestone, though some are of granite, and are rounded or slightly lenticular in shape. The gravel is beautifully interstratified with beds of sand, and is arranged in finer and coarser layers, the pebbles increasing in size, from above, downwards.....	8 0
Gravel, similar in character, but not so well rounded, a few of the limestone pebbles showing glacial striæ.....	1 6
Fine yellowish quartz sand very irregularly interstratified with coarse sand, gravel and plastic clay.....	1 9
Very coarse sand or fine gravel.....	7
Plastic yellow clay	1 6
Unstratified light gray sandy clay or till holding polished and striated pebbles and boulders of gneiss, limestone, &c.....	35 0

The line between the last two is very indistinct. In this section just at the top of the bed of fine rounded gravel a number of sharp-angled and apparently chipped fragments of quartzite were found. Two of them were roughly in the shape of arrow heads, and one was a very thin flake. The others were very irregular. Associated with them was a broken fragment of one of the toe bones of a moose or elk. These irregular fragments were all lying with their longer axes horizontal, and were overlaid by a sandy loam, which had apparently been deposited as a coarse sand, and which has since been affected by weathering and by the growth of vegetation over it to about the depth at which these "chipped flint" are lying. This slightly loamy sand is plainly though not very clearly stratified and includes towards the bottom, and above the "chipped flints" many thin water-worn lenticular pebbles of shaly or thin bedded limestone.

A mile north-east of this ridge, another ridge runs away to the north-west, and for a mile below it the banks of the river show dark gray unctuous clay shale to a height of from fifteen to twenty-five feet. At the end of this mile the banks become low and sloping for a mile at least, and a man who was with me stated that he had been down the river for four miles further and the banks continued of the same character throughout. Wherever seen the unctuous Cretaceous shale contained some fragments of the shells of *Inocerami*.

Where the banks fall away another gravel ridge crosses the country, Low country. and is said to continue towards the north-west, though it was impossible to follow it rapidly through the thick woods.

The ridge west of it, with an elevation of 1,084 feet, was, however, Pitching followed for a long distance. Its surface is underlaid by fine gravel, ridge. and is generally even and lightly covered with short grass, forming a grassy plain from 100 to 200 paces wide.

On either side is a fringe of stunted oaks beyond which the ground is very swampy and is thickly wooded with poplar and spruce. The ridge is quite level, resembling a beautiful gravel road running between long rows of trees. For five miles it runs N. 20° W., maintaining the same open, avenue-like character. At the end of this distance it is cut across by Drifting River, a small stream flowing south-eastward to join the Drifting Valley River. Its valley is here forty feet deep and a quarter of a mile River. wide, and is very thickly wooded with maple and willow. Beyond this break of a quarter of a mile the ridge is again encountered, but for a mile and a half it is very irregular, being in some places almost cut away by Drifting River, which here flows southward along its western side. Beyond the point where the creek first strikes the ridge it is again beautifully rounded with a width of 150 feet and rises about ten feet

Pine Creek
trail.

Fork River.

Indian village

Ridge be-
comes wooded

above the level of the surrounding country. Three-quarters of a mile from the creek the cart trail to Pine Creek joins this ridge, coming from the one to the west of it, and the ridge then continues for thirteen miles almost due north to Fork River, being in this distance broken through by two small streams flowing eastward, the beds of which are covered with pebbles and gneissoid boulders, but neither of them show any indications of shale or rocks of local origin. Throughout the southern part of the distance the ridge was lightly wooded with poplar, after which it is thickly wooded with heavy poplar, and long marshes or shallow lakes extend along its western side. Around these there is some good white spruce, most of which have lately been burnt. At the end of this distance, Fork River, a small stream ten feet wide and two feet deep, cuts across the ridge from the west. On the west side of the ridge and south of the river a beautiful wide grassy meadow stretches for several miles to the south, on the north end of which, close to the stream, is an old Indian shanty.

For the next eight miles the summit of the ridge was not followed, but for the most part, if not for the whole distance, it could be clearly seen from the cart trail to the west. In north latitude $51^{\circ} 38' 15''$ the cart trail comes again to the ridge and after following it northward enters a grove of large spruce, in which it crosses South Pine Creek, here twenty-five feet wide. Beyond this stream the ridge is found to present a beautiful open, though narrow stretch, a mile in length with the river flowing southward along its western side and a spruce forest to the east, until a small Indian village is reached. Here a band of Indians from Pine Creek Reserve pass the winter in small but substantial log houses. They obtain an abundant livelihood by hunting and trapping in the immediate vicinity. Moose, bear, otter beaver, marten, fisher, fox and skunk are the principal game.

From this village a cart trail thirty miles in length strikes off to the Hudson's Bay Company's post and Indian Reserve, near the mouth of Pine Creek. This trail is described on a succeeding page.

From the Indian village on South Pine Creek the ridge continues in a direction N. 25° W., being generally low but moderately well defined. It is wooded with small aspen, among which are scattered a few stunted oaks. To the west, a meadow, a quarter of a mile wide, follows the ridge for several miles, while to the east is a thick growth of small spruce. Five miles north of the village the ridge is cut across by Little Pine Creek (*Minégo Sipi Wanichan-sin*, The Child of Pine Creek), a small stream twelve feet wide flowing over a bed of pebbles and boulders. It is said to flow into North Pine River. Two miles and a quarter further north another small tributary of North Pine Creek,

about six feet wide, crosses the ridge. Between these two creeks the ridge is twice broken through, first by a narrow gully that possibly at one time was the channel of Little Pine Creek, and secondly by a wide shallow depression.

North of this small tributary the low gravel or sand ridge was followed for three miles and then for one mile was lost in a heavy spruce and poplar forest south of North Pine Creek. North of North Pine Creek it was further followed as a low but still distinct ridge for three miles, until an accumulation of heavy timber and windfall made it necessary to leave it, and to strike westward across a tamarack swamp to an almost vertical escarpment sixty feet in height, along the foot of which is a line of rounded cobbles, apparently on the level of the next higher Lake Agassiz beach. The total distance through which this gravel ridge has been practically continuously traced northward from Wilson River is fifty miles. Time would not permit of levelling it instrumentally, but a careful series of barometric readings seem to show that it is about a hundred feet higher at the northern than it is at the southern end, having a rise northward of about two feet to the mile. This agrees closely with the observations already made on these beaches in Southern Manitoba and the adjoining States.

A typical example of the country west of Lake Winnipegosis may be seen along the cart trail from the ridge just north of South Duck River to the Hudson's Bay Company's trading post, near the mouth of Pine Creek. East of the Indian village the trail runs eastward for four miles and a half, through country wooded with small spruce and poplar, across tamarack swamps, and little sandy plains sparsely wooded with Banksian pine, to a rounded ridge of sand, twelve feet in height, through which South Pine Creek flows in a comparatively shallow channel. This sand ridge has an elevation, as determined by the barometer, of 1,047 feet. The trail follows it in a N.N.W. direction for a mile, and then leaves it and turns north-eastward for two miles across a willowy or grassy plain, often underlaid by sand, to another ridge about thirty feet below the last, composed of sand and small gravel. It also has an elevation of about twelve feet above the surrounding country, an average width of 150 feet, and is lightly wooded with small poplar and large Banksian pine.

The trail continues northward on this ridge for a mile, and then turns north-eastward, and, after crossing a level tract of country, ascends the point of a sandy ridge with about the same elevation as the one just left. This ridge is also followed by the trail for a couple of miles, in which distance it is interrupted in places, and generally has an extensive sandy plain stretching away to the north-west of it. In

places it is lightly wooded with Banksian pine, poplar, and a few small oaks.

Ford.

Two miles and a half from the north-eastern end of the ridge the trail crosses Pine Creek at a good ford, over rounded boulders and cobbles of gneiss and dolomite. From the crossing, north-eastward to the trading post, the trail is never at any great distance to the south-east of the river. For the first three miles it crosses an almost level plain, generally overgrown with willows, with here and there burnt stumps of spruce and poplar, and on which are tracts more or less thickly scattered with boulders. On this plain the old location of the Canadian Pacific Railway is crossed, and near it a well rounded gravel ridge, 200 feet wide and six feet above the surrounding country. The elevation of this ridge, as given by the Canadian Pacific Railway survey, is 960 feet above the sea. Thence the road passes over grassy plains and through poplar woods, in which a few boulders may occasionally be seen. A few low and intermittent sandy ridges, the heights of which were not determined, mark old shore lines of Lake Agassiz.

Old location
C.P.R.

Upper pitch-
ing ridge.

Returning to Valley River a high, well-defined gravel ridge has already been recorded a mile to the west of the one followed, and about fifty feet above it. On this ridge the cart trail to Pine Creek, and the ancient hunting trail of the Indians to the eastern face of Duck Mountain, starts northward from Valley River. The ridge is also well defined southward to Wilson River, and is probably continuous with those most strongly marked near the face of the escarpment on Vermilion and Ochre rivers.

Small lake.

For four miles northward from Valley River it is gently and evenly rounded, rises twelve feet above the level of the surrounding country, and finally spreads into a gravel plain a quarter of a mile wide. Southwest of this plain is a small lake of beautifully clear water, to the east of which, extending across the gravel ridge, is a fine grove of oak. Very few boulders were seen on the ridge, but some were found near the border of the lake, chiefly of grey and reddish gneiss, but one was of dark green trap, and a few were of Palaeozoic limestone.

After passing through the grove of oak the ridge is again seen stretching towards the north as a long line of grassy prairie through the centre of a forest of spruce and poplar. A mile and a half north of the lake Drifting Creek strikes the western side of the ridge and from there follows it for two miles, till at length it cuts through it in a valley twenty feet deep, but quite narrow. This stream is flowing over a bed of boulders and pebbles derived from the superficial deposits, and shows no signs of the underlying Cretaceous rocks.

Drifting
Creek.

On the north side of Drifting Creek the ridge becomes wooded with poplar and the cart trail leaves it, and strikes eastward over a flat

marshy tract covered with dead poplar and willow until the ridge already described is reached, up which it turns as far as Fork Creek, when it again turns westward and after crossing Fork Creek reaches a ridge which is at the same elevation above the one we have last followed as the main ridge at Valley River, of which it is doubtless a continuation.

Fork Creek is a small stream ten feet wide and two feet deep at this Fork Creek. point. It rises on the eastern face of the Duck Mountain, and flows eastward to join the Mossy River in the north-east corner of township 29, range 20 W. For much of its course it flows through a more or less low swampy country, and its water is consequently of a decidedly brownish colour. At the trail crossing, just below the upper of these two ridges, its bed is composed largely of limestone pebbles as well as boulders and pebbles of gneiss, but there are also many fragments of a rather hard grey clay shale. The upper course of the stream is entirely through drift deposits, but close to the last-mentioned gravel ridge horizontal dark grey clay shale, representing the summit of the Benton or the base of the Niobrara shales, is seen in several small exposures close to the edge of the water. Cretaceous shale.

From the camping place on the Pitching Ridge, just north of this creek, and at an elevation of 1,180 feet above the sea, a pack trail turns off to the west. Where this trail crosses the creek a low sandy ridge, ten feet higher than the last, runs N.N.W., and a mile further along the trail, or two miles from the Pitching Ridge, a well-defined ridge of rounded water-worn gravel, with an elevation of 1,235 feet above the sea, rises six to eight feet above the level of the surrounding country. Its general bearing is N. 25° W. Two miles further along the trail, another ridge from 300 to 400 feet wide, ten feet high, and 1,287 feet above sea level runs off parallel to the last, and consists, like the others, of rounded gravel. Half a mile beyond this is another low ridge of rounded gravel, and three-quarters of a mile beyond it again is yet another similar ridge, with an elevation of 1,365 feet above the sea, well defined where there is low land behind it, but in other places it is less distinct where it is backed by low cliffs, that have formed the shore when the waters of Lake Agassiz stood at the height of this ridge. This is the highest level that the water appears to have reached.

West of this highest ridge the country becomes more undulating, Undulating country. and the soil is a dark, sandy clay, covered with numerous pebbles and boulders, which are all more or less distinctly angular, and show no sign of having been rounded by water action. They are simply weathered out of the underlying boulder-clay which everywhere forms the surface.

Upper pitch-ing ridge.

North of Fork Creek the Pitching Ridge is evenly rounded, and about twelve feet above the level of the surrounding country, consisting, on the top at least, of fine, rounded, water-worn gravel, with pebbles chiefly of limestone. A prairie area here has evidently been a favourite camping ground for the Indians. From here the ridge follows a general direction of N. 20° W. For three miles and a half it is open or lightly wooded with poplar, and carts were taken along it without much difficulty, but at the end of this distance it is cut across by a small tributary of Fork River, twelve feet wide and a foot deep, flowing in a rather shallow valley 700 feet wide, and thickly wooded with large spruce.

After crossing this creek the cart trail again turns to the north and leaving the ridge continues through a forest of large poplar and spruce to a long open meadow lying west of the lower ridge already described. This meadow in 1889 was moderately dry and covered with long grass, while a lake a mile and a quarter long extended through it, but in years of high water it is doubtless an impassable marsh. The trail follows the meadow in a N.N.W. direction for three miles, with a forest of small spruce and tamarack to the west, and then rises a few feet to the top of the lower ridge.

Travelling northward in 1887 the carts were left on the higher ridge south of the tributary of Fork River, and the course of the ridge was followed on horseback and with packhorses.

Ridge more sandy.

North of the creek the ridge becomes thickly wooded with heavy poplar and spruce, but still it is well defined though now often more sandy than was usual further south. To the west it is bordered by a grassy marsh, while towards the east lies an extensive spruce-covered swamp. The ridge here, and as far north as we followed it, maintains the direction N. 20° W.

South Pine River.

For five miles it continues to maintain much the character of that just described, when it is cut across by South Pine River, a stream of clear brownish-coloured water thirty feet wide and two feet deep with sandy banks covered with a deep coating of moss or sedge. Its bed is a coarse rounded limestone gravel, and there is no sign on it of any of the underlying Cretaceous shales or sandstones.

North of South Pine River the ridge for a mile is an open grassy prairie, beyond which it begins to be more and more thickly wooded, till six miles north of the above river the pack trail leaves it and turns on to the lower ridge. For the next three miles it was not followed, though it was often seen to the west of the trail, but it was again reached on the banks of North Pine River. It was followed north-north-westward for a mile and a half, when it became so covered

with a heavy windfall of burnt spruce and poplar that further travel along it was impossible. Its summit here has an approximate altitude of 1,250 feet above the sea.

When the trail leaves the lower ridge a short distance further north, it ascends the face of a steep escarpment sixty feet in height, which would appear to have been cut by the waves of Lake Agassiz when its waters formed the beach that we have last been following. The top of the hill is pretty thickly scattered with boulders, and the hill itself is probably a glacial accumulation of the character of a moraine or drumlin.

Throughout all the distance that this ridge was followed north of Fork Creek, it maintained much the same character, being from 150 to 250 feet wide, and six to eight feet above the level of the surrounding country, rising on both sides with an easily rounded slope, and almost level on the top. The top generally consists of sand or fine gravel, which becomes coarser at a depth of a few feet, as can be seen in places where trees have been blown down, and their out-torn roots have left deep holes in the otherwise level surface.

All these ridges are doubtless connected with some of those to be described further north, but the country is so densely wooded that it was impossible to follow them continuously.

From the trail on the Pitching Ridge another trail branches to the west up North Pine River, on which several high gravel ridges are crossed, and from which many good exposures of the underlying Cretaceous shales may be seen. As far as the writer's observation went, the lowest exposure of these shales on the river is on its north bank where it cuts through the Pitching Ridge last described. The following descending section is here shown:—

North Pine River.

Benton shale.

	ft. in.
Horizontally stratified gravel, with pebbles of gneiss and limestone up to three inches in diameter.....	6 0
Light gray unstratified till, with irregular pebbles and a few boulders. The lower portion almost entirely local.....	10 0
Dark gray thin-bedded clay shale.....	4 0
Soft white clay, with sweetish taste.....	0 6
Dark gray thin-bedded clay shale, with many small crystals of selenite, to water.....	6 0

The clay and shale appear to represent beds about the summit of the Benton formation.

The trail runs along the top of the south bank of the valley, on gradually rising ground, through poplar woods. The valley gradually becomes deeper, and a quarter of a mile or more in width.

Niobrara
shale.

About a mile up the valley from the Pitching Ridge the bank shows the following section :—

	ft. in.
Light brown sand.....	5 0
Soft light gray mottled shale in thin beds, weathering into small flakes, and forming a steeply sloping cliff	15 0
Hard white clay.....	0 1
Light gray mottled chalk marl.....	5 0
Hard white clay.....	0 2
Soft light gray mottled chalk marl or marlite in beds ranging in thickness from three inches down to a thin shale, and weathering into a vertical cliff. It con- tains many shells of a large <i>Inoceramus</i> , <i>Ostrea</i> <i>congesta</i> ?, fragments of fish bones, and many foraminifera, among which <i>Globigerina Cretacea</i> is particularly abundant.....	5 0

These shales and chalk marls are typical of the Niobrara formation.

Half a mile further up the river, and just east of the trail crossing, a similar excellent exposure of foraminiferous Niobrara shale may also be seen.

Trail crossing

At the crossing the valley is seventy feet deep, with wide stretches of level bottom land, through which the river winds in a channel filled with boulders. West of it the trail continues along the north side of the valley for nearly five miles. For the first mile and a half it passes over a sandy tract, generally wooded with Banksian pine, on which three gravel ridges are crossed at respective elevations, as determined by aneroids, of 1,383, 1,402, and 1,439 feet above the sea. Opposite these the valley is 100 feet deep, and the banks are composed of till from which a large number of boulders are falling, while the bed of the river is filled with large boulders.

Delta plain

West of the highest of the three ridges just mentioned, the trail passes for a mile and a quarter across a wide plain, thickly wooded with small Banksian pine, and chiefly underlaid with brown sand and water-worn pebbles, some of which are as much as eight inches in diameter, though for the last quarter of a mile the soil is finer and more silty, and over the silt a few boulders are scattered. This sandy plain would appear to have been an old delta deposit formed by the prototype of North Pine Creek, when Lake Agassiz was at one of its highest stages. There is a rise of forty or fifty feet from its eastern to its western side. The river, opposite this latter point, flows in a valley fifty feet deep, ten feet of this being its immediate channel. Twenty feet above the river is a terrace stretching from bank to bank of the valley, underlaid by alluvial gravel consisting of pebbles and boulders up to a foot in diameter, of gneiss and Devonian limestone.

For the next two miles and a quarter the country is rolling or hilly, Moraine, many of the hills being literally covered and probably largely composed of boulders, chiefly of gneiss. The whole tract is clearly morainic. Here the trail reaches the river which is twenty-five feet wide, and approximately 1,627 feet above the sea. Just above this point, and on the north side of the river is a bank, fourteen feet high, showing from top to bottom light slate-gray horizontally stratified clay shale, breaking down readily into small angular fragments. The beds clearly belong to the Pierre formation, and doubtless to its lower Pierre shales. portion. Though no large and typical fossils were observed, the shale, under the microscope, was found to contain many radiolaria apparently similar to those found on Bell River, but generally so corroded that Dr. Rüst, who described those from the latter place, was unable to identify the species.

This exposure of Pierre shale is close to the foot of the main escarpment of Duck Mountain, where North Pine Creek emerges from it in the bottom of a wide sloping valley from 300 to 400 feet deep. Wherever any other scarped banks were seen on its sides, they appeared to consist of light gray till.

On the south side of the valley a long esker rises to a height of 150 ft. Esker. feet above the bottom land, and a scarped bank on its southern side shows the following section :—

	ft. in.
Light yellowish gray unstratified clayey till, containing many irregular striated pebbles of limestone and gneiss.....	6 0
Cut off obliquely by, and lying unconformably under the above is a light yellowish-gray, horizontally stratified, fine sand or silt, free from pebbles.....	3 6
Coarse red sand and small pebbles.....	0 4
Fine sand, slightly coarse at bottom.....	1 9
Stratified gravel, with pebbles up to four inches in diameter imbedded in a matrix of coarse sand. A number of the pebbles are of a light gray till, different, however, from that above.....	5 0
Horizontally stratified fine light brown sand.....	3 6
Very light gray slightly coarse sand.....	1 0
Covered.....	50 0
Dark gray, horizontally stratified, tenacious clay or clay shale.....	1 0

The summit of the mountain to the south, as well as its face, is strewn with boulders of Archæan gneiss, &c., and Devonian limestone.

Following the Indian hunting trail northward from North Pine South Duck River, a branch of South Duck River is crossed in north latitude 51° 52'. It is twenty feet wide and flows over a bed of gravel in a narrow

South Duck
River.

valley through the ridge. The banks are composed at the bottom of twelve feet of light gray mottled Niobrara shale holding *Ostrea congesta*, above which are thirty-four feet of badly exposed interbedded layers of till and stratified sand and gravel.

A short distance north of this stream the trail reaches a well rounded gravel ridge, with an elevation of about 1,360 feet above the sea ; and five miles north of the last mentioned stream it crosses the main branch of South Duck River which here flows in a valley seventy feet deep, with a channel thirty-five feet wide. From the top of the ridge a beautiful view can be had of the wooded face of the Duck Mountain, where a dark line of heavy spruce forms a rich background to the lighter green of the intermediate poplar forest, while the distant sky line rises and falls in easy undulations.

The almost vertical bank of the valley beneath shows the following section of Lake Agassiz deposits and Niobrara shales :—

	ft. in.
Stratified light brown sand underlaid by gravel.....	22 0
Dark gray horizontal fissile mottled clay shale holding fragments of <i>Ostrea congesta</i> ?, <i>Inoceramus</i> sp. ; and a few small species of foraminifera.....	14 0
Light gray mottled clay shale, the beds becoming thicker below.....	31 0

A mile further north, in a low exposure of similar shale on the banks of the same river, *Belemnitella Manitobensis* and *Loricula Canadensis* were also found.

Trail to Duck
Mountain.

Between these two streams, at a small grove of oaks, a bridle trail turns off the ridge towards the west. For a mile and a quarter it runs through poplar forest, passing a beautiful grove of large elms, and then for three-quarters of a mile follows a gravel ridge with an elevation of about 1,400 feet above the sea. From this ridge it makes straight up the easy slope of the side of the mountain, through woods of poplar and spruce, and over hills often thickly strewn with boulders, to some small brooks flowing into North Pine River. Here the country becomes thickly wooded with small pine and tamarack, and the trail strikes across stony morainic hills to the head of Favell River.

Sand spit.

Returning to the east side of the mountain, the main trail follows the ridge for two miles and a half north of the crossing of South Duck River, and then turns north-eastward and runs through a tamarack swamp, intersected by drier belts covered with poplar, and over land composed largely of sand and boulders, to the north point of an old sand spit or beach fifty feet in height. This beach stretches away to the south, and is generally composed of rounded gravel, though its surface

is also thickly strewn with boulders. Its summit has an approximate elevation of 1,290 feet above the sea.

Along its eastern side, and fifty feet below it, runs another well defined ridge of rounded gravel, which continues northward to North Duck River, just north of which it is crossed by the old location of the Canadian Pacific Railway, at an elevation of 371 feet above Lake Winnipegosis, or 1,199 feet above the sea. Another similar ridge is also crossed by the old location survey, a short distance further east, at an elevation of 1,149 feet above the sea.

The North Duck River where crossed, close to the foot of the ridge, is thirty-six feet wide, and on the 10th of October, 1887, was six inches deep, with a bed of sand and pebbles. The banks were all of stratified gravel, and nothing was seen of the underlying Cretaceous beds.

Beyond North Duck River the ridge continues northward for about three miles, in which distance it is often scattered with many boulders of gneiss. At the end of this distance it turns to the west around the north-eastern angle of Duck Mountain, and runs up the valley of Swan River, but it was not definitely followed further.

SWAN RIVER AND TRIBUTARIES.

Swan River rises on the western side of the Porcupine Mountain and flows in a general south-easterly direction to the crossing of the Second Initial Meridian. A brief account of this portion of the stream is given by Prof. Macoun in the Rep. of Dept. of Interior, 1881, pt. I., pp. 81-85.

A short distance below the crossing of the Second Initial Meridian Snake Creek flows into Swan River from the south, in a deep wide glacial valley, which is a continuation northward of that followed by the Assiniboine below Fort Pelly. Snake Creek rises in a marsh north-west of Fort Pelly and close to the elbow of the Assiniboine River, and I am informed that in high water, when this river overflows its banks its waters run into Snake Creek and Swan River.

On the east side of Snake Creek valley, just above its mouth, is an Prairie. extensive triangle-shaped prairie, sloping from the higher land to the south-east to within about ninety feet of the level of Swan River. This prairie is irregularly undulating, in some places being almost level, in other places low rounded hummocks alternate with shallow depressions, but everywhere it is thickly covered with boulders of reddish and greenish gneiss from two to three feet in diameter. The valley of

Snake Creek to the west of this prairie is about 1,500 feet wide and seventy-five feet deep, while towards the west its banks rise into a prominent spruce-covered ridge. Close to its mouth the valley is blocked by high rounded boulder-strewn morainic hills, through which the creek has again cut a narrow channel.

Police barracks.

On the northern side of the above prairie the Mounted Police had a large barrack which was burnt by a prairie fire in 1884. The place where the fort stood is now strewn over with charred wood, pieces of rusty iron, &c.

Half a mile south of the old fort, the telegraph line on the old location of the Canadian Pacific Railway crossed this prairie from east to west, and here the town of Livingstone was intended to have been laid out. The level of the bottom of Snake Creek valley, as laid down on the profile of the old location of the Canadian Pacific Railway, is 567 feet above Lake Winnipegosis, or 1,397 feet above the sea.

Swan River bore.

On the alluvial flats close to the banks of Swan River and a few paces east of the mouth of Snake Creek, Dr. Selwyn in 1874 and 1875 had a bore-hole sunk to the depth of 501 feet to ascertain quickly and certainly whether coal was to be found in any considerable quantities within working distance of the surface. The height of the surface here as compared with the nearest points on the old location was found to be about 1,360 feet above the sea.

"The specimens of the strata taken out are nearly all of dark blue, gray or black shale, and hold *Inoceramus*. At 259 feet a calcareous band, about nine feet thick, was passed through. This and the lowest twenty feet of shale, rather slaty, show organic remains, small spines and fish scales."*

The shale here passed through is probably the same as that seen lower down on Swan River, and belongs to the Niobrara formation of the Cretaceous.

Swan River.

Following the river downwards from the mouth of Snake Creek, Mr. Dowling saw some small exposures of dark gray clay shale, mixed with some thin bands of white unctuous clay; and on the bars in the river, at the crossing of the trail from Fort Pelly to Swan Lake, a large number of fragments of dark gray clay shale, mixed with clay ironstone, near which were found pieces of sandstone, holding *Ostrea congesta*? A short distance below the crossing, dark gray friable rather soft clay shale is sliding out of the bottom of the bank, mixed with some dark brown clay ironstone.

*Alfred R. C. Selwyn. Rep. of Prog. Geol. Survey, 1875-76, p. 292.

An alluvial flat occupies the bottom of the valley, which is here Valley. half a mile wide and 150 feet deep. Through the alluvial deposit the river has cut a winding channel that but seldom impinges on the sides of the valley, which are doubtless chiefly composed of Cretaceous rocks.

The sides of the valley are everywhere sloping and covered with small aspen. In many places the bottom is open and grassy, but the river channel is always fringed with willow and ash-leaved maple.

For eight miles from a point two miles below the crossing place, the river was not examined, but, where seen, three miles above the mouth of Bear's Head River, the valley was but thirty-five feet deep, and the immediate banks were low and thickly wooded. The river was 150 feet wide, with a bed of large boulders, over and through which the water was flowing.

Half a mile below Bear's Head River, the banks of Swan River Niobrara are sixty feet high, and show at the bottom fifteen feet of horizontally shale. bedded dark gray clay shale of the Niobrara formation, including harder calcareous bands, holding *Inocerami*, oysters and bones and scales of fishes. Nodules of iron pyrites are also falling from the face of the bank.

This shale is overlaid by three feet of light gray unstratified till, Till and sand. holding many polished and striated pebbles, on which is resting eight feet of coarse red stratified sand and gravel. Copious springs of water, highly charged with calcareous material, flow from this bed, and form a heavy tufaceous deposit on the face of the cliff. The sand is overlaid by several feet of light gray laminated clay.

Half a mile further down the river, where the bed of the stream has an elevation of about 1,240 feet above the sea, the bank is thirty-five feet high and its bottom is composed of dark gray clay shale, holding bands of soft limestone, in which were found fragments of *Inocerami*, *Ostrea* Niobrara *congesta*, *Serpula semicoalita* and *Belemnitella Manitobensis*. This is limestone. overlaid by a coarse reddish stratified sand, which, within a short distance, is either quite loose, loosely cemented together by calcareous material into a soft friable sandstone, or bound together by calcareous or ferruginous cement into a hard sandstone, or conglomerate. It is quite evident that this is the same deposit as the sand overlying the till at the last named exposure. This sand is overlaid to the surface by twelve feet of more or less distinctly laminated light gray clay.

North-west of this part of the river, and at a distance of about four Thunder Hill. miles from it, Thunder Hill rises as a high isolated prominence from the middle of the plain. Its height, as given on the plans of the old

Thunder Hill, location of the C. P. R., is 1,167 feet above Lake Winnipegosis, or 1,997 feet above the sea. The height as determined by two aneroids during 1887, was 1,848 feet, and allowing that there was some point a little higher than that reached, the highest point would not exceed 1,900 feet, which may therefore be taken as the true height of the hill. The following section was measured by Mr. Dowling, who collected specimens of the different beds. The rock was usually seen in small isolated exposures.

At the summit, at an altitude of 1,848 feet, were twelve feet of drift deposits, holding numerous small irregular pebbles. This would appear to be till.

Immediately below it lies a soft dark gray unctuous Cretaceous clay shale, holding a thin band of soft white clay, to a thickness of eleven feet at least, often stained with a yellow incrustation. At a height of 1,770 feet is an exposure of about thirty feet of a rather hard soapy shale.

Niobrara shale.

At a height of 1,750 feet is the top of an exposure showing ten feet of light yellow clay shale, below which is fifty-five feet of a light gray chalky shale, descending about the middle into a chalk marl at 1,715 feet, and at the bottom showing a band of a hard gray limestone holding several fossils, viz., *Ostrea congesta*, *Inoceramus* sp. with very thick shell, *Inoceramus*, possibly a large form of *problematicus*, and *Cladocyclus occidentalis*. The chalk marl also contains several genera of foraminifera, viz., *Textularia*, *Discorbina* and *Globigerina*, with Coccoliths and Rhaboliths. Below this the face of the hill is covered with slides and the country slopes away to the level of the plain.

Extension of the terrane.

The band of limestone or chalk marl, which is here seen at an elevation of 1,700 feet, is very similar to the Niobrara limestone on the Valley, Wilson and Vermilion rivers, ninety miles S. 35° E. from this exposure, where it has an approximate elevation of 1,200 feet. 105 miles further in the same direction, in section 36, township 8, range 11, and at an elevation of about 900 feet above the sea, a band of hard gray limestone, ten feet thick, outerops on the banks of the Assiniboine. It is very similar to the lowest calcareous band on Thunder Hill, and contains precisely similar fossils. In all three localities the marl is overlaid by a dark gray clay shale, which in both of the southern exposures, at least, would appear to belong to the Pierre formation.

Thickness of the terrane.

The greater height at which the chalk marl and limestone occur in Thunder Hill may be due to the light south-westerly dip of the strata, or it would appear more probably to be due

to a thickening of the underlying Cretaceous sandstones and shales, as all the information at hand goes to show that the underlying Palaeozoic limestones are practically horizontal on their extreme western outcrop, from Mossy River to the east end of Red Deer Lake. If these limestones extend horizontally under the shales of the Duck and Riding Mountains, the Cretaceous beds lying below the layer of chalk marl would show a thickening of 500 feet on going north-westward from Vermilion River to Thunder Hill. If an even dip towards the south-west is assumed from the line of outcrop of the limestones, the evidence of thickening would be still stronger in favour of a thickening of the Niobrara-Benton formation towards the north-west, for while the outcrop on the side of Thunder Hill is forty-two miles from the approximate line of outcrop of the underlying Palaeozoic limestones, the outcrop on Vermilion River is only about twenty-eight miles from the same line, so that any dip of the surface of the limestone in this direction should show a still greater increase in the thickness of these beds towards the north-west. That the surface of the underlying limestone does not rise towards the south-west from its line of outcrop, is shown by the bore-hole that was sunk near the mouth of Snake Creek, the bottom of which is about the same level as the surface of Swan Lake.

Returning now to Swan River the next point examined, below the exposures near the mouth of Bear's Head Creek, was about five miles east of Thunder Hill, where the river makes a sweeping bend towards the north. The banks are here about thirty feet high, and consist of fine, regularly stratified sand. Four miles further down the river, one of the gravel ridges, of which mention has already been made, crosses the valley, its surface being open and grassy. It is locally known as the "Square Plain," and consists, like the other similar ridges, of rounded water-worn limestone gravel. No complete section of it was seen, the upper twenty feet was covered with slides, but the lowest fifteen feet, down to the river, consists of unstratified glacial till, Till holding many finely striated pebbles. The underlying Cretaceous beds are entirely concealed.

River banks
of stratified
sand.

For twelve miles north-east of the "Square Plain" the river was hastily examined, but its banks appeared to consist entirely of superficial deposits.

The underlying Cretaceous rocks now reappear, but their character is different from that of the shales near Bear's Head River. The dark gray unctuous clay is present on the top, below it the clay is lighter in colour and more compact, and is interbedded with layers of sandstone.

Near Tamarack Creek.

Two miles below Tamarack Creek the following section is exposed on the north bank of the stream :—

	ft. in.
Light coloured stratified sand	4 0
Very irregularly stratified soft plastic clay	6 0
Bed of same containing numerous large pebbles.....	1 6
Light yellow horizontally stratified fine-grained slightly clayey sand, containing a few striated pebbles....	15 0
Band of dark Cretaceous clay with small irregular concretions of pyrite.....	0 2
Horizontally stratified fine white very soft sandstone, streaked with bands of red and black.....	2 3
Similar sandstone containing large red lenticular nodules of hard sandstone.....	0 9
Soft white sandstone with dark bands.....	6 6
Covered	3 0

Stratified dark blue clay at the bottom of which is a band of hard sandstone containing a great number of well-preserved specimens of an *Ostrea* like a large and clustered variety of *O. congesta*, with *Modiola tenuisculpta*.

Dakota sand-stone.

A short distance further down the river, under fifteen feet of alluvial deposits, is shown seventeen feet of white soft false-bedded sandstone containing thin layers of dark coloured very plastic clay. Below this clay are two feet of lamellar hard brown sandstone, which is again underlaid by six feet of lead coloured soft unctuous clay in which, near the top, is a thin very irregular bed of impure lignite, much of which has been replaced by pyrite. This lignite is sometimes associated with nodules of ironstone which contain fragmentary remains of plants.

The sandstone and light gray clay extend for a mile or more down the river, the face of the hard band of brown sandstone being in one place quite rounded off and covered with longitudinal glacial scratches, but it is impossible to make out their exact direction as the blocks that formed the point of the band have all been more or less displaced.

Last Cretaceous outcrop

A short distance further down the stream, where an ancient lake terrace crosses the country and the river flows out to the lower plain from a valley seventy feet deep, and extends away to the north-east in a shallow winding channel, the underlying Cretaceous rocks are seen for the last time in descending the river.

The section here is as follows :—

	ft. in.
Plastic stratified superficial clay.....	8 0
Unstratified clay with a few pebbles lying unconformably on, and filling the irregularities in the underlying rocks (till)	8 0
Fine white soft stratified Cretaceous sandstone.....	2 4

	ft. in.
Dark gray sandy shale.....	2 2
Soft white and light yellow sandstone with intermingled beds of dark gray clay shale.....	5 6
White sand and dark gray clay shale thinly interbedded	3 0
Soft plastic dark gray clay shale.....	4 6
Thin band of small fragments of lignite.....	0 $\frac{1}{2}$
Hard lead gray clay shale weathering into rounded butte-like shapes.....	12 0

Partially imbedded in this shale was lying a considerable mass of Lignite. lignite showing all the details of its woody structure. It consisted of the partially carbonised trunk of a large tree which had fallen and become imbedded in the shale. All the lignite seen on Swan River was of this character, nowhere having become compacted into regular seams. A specimen now in the Geological and Natural History Museum in Ottawa, collected by Mr. J. W. Spencer in 1874 on Swan River, is also of precisely the same character and has evidently been broken from a carbonised tree-trunk buried in the shale.

The above sandstones and light gray shales differ considerably from the soft unctuous shales, limestones and marls that have been already recognized as belonging to the Niobrara-Benton subdivision of Meek and Hayden's typical Nebrasca section, and which have been together designated the Colorado group by Dr. C. A. White. They also undoubtedly underlie these shales and limestones. They therefore correspond, both in position, and to a certain extent in character, to the typical Dakota sandstones of Meek and Hayden. Very few fossils have been found in them, but those that are known, favour this view of their age, and the absence of all the species found to occur in the overlying beds, is suggestive of a difference in age.

The approximate elevation of these beds where last seen is 150 feet above Swan Lake, where the Devonian limestone occurs in many places.

Let us now examine the banks of Rolling River, which flows into the Swan River four miles below the last-mentioned exposure of Dakota sandstone, and which, with its tributary the Favell River, drains a considerable area in the northern part of the Duck Mountain. The upper portion of the east branch of Favell River was not examined, but the west branch, and Rolling River in their upper portions, before they leave the mountain, show nothing but drift deposits, and in descending them it is not until these streams cut a deep gully through a high ridge lying some distance from the foot of the main escarpment of the mountain, and known to the Crees as Minitonas, or Isolated Hill, that the Cretaceous rocks are first seen.

Minitonas.

The Rolling River, where it reaches this hill, at a point two miles above the old location of the C. P. R., is 1,300 feet above the sea. The banks are 100 feet high and composed of slate grey mottled calcareous clay shale, holding remains of *Inoceramus problematicus*, *Ostrea congesta*, *Enchodus Shumardi* and *Cladocyclus occidentalis*. Forty feet at the bottom is soft and quite shaly, while the rock above becomes harder, more compact and much more calcareous. It breaks with an irregular fracture, is much jointed, and stands out as a bold vertical cliff overhanging the sloping bank of softer underlying shale.

Niobrara-Benton shale

For a mile northward from where this first exposure of shale is seen, both sides of the winding stream show alternate outcrops of dark bluish-gray friable clay shale similar to the lower portion of the first-mentioned outcrop, and from which, in several places, issue springs of clear cold water smelling very strongly of sulphuretted hydrogen and leaving a white coating of sulphur on stones or other objects over which they flow. The river is here bounded to the east by a bank 120 feet high. The lowest fifty feet consist of the dark gray clay shale just mentioned, above which twenty feet of the bank is hidden, being covered by land slides. The upper fifty feet consist of fine-grained stratified sand very similar in character to that seen on the banks of Swan River, a short distance below the mouth of Bear's Head River.

Benton shale.

At this high bank the river turns sharply in a direction N. 65° W., to about half a mile beyond the crossing of the old location of the Canadian Pacific Railway, a distance in all of two miles and three-quarters. For a mile and a half, dark gray clay shale, similar to that already mentioned, crops out in low exposures close to the edge of the water, beyond which the banks for a long distance are composed entirely of boulder-clay and alluvial deposits. The lowest outcrop of Cretaceous rocks seen was at an approximate elevation of 1,200 feet.

Favell River.

On the west branch of Favell River where it flows round the eastern point of Minitnas, the bed of the stream is at an elevation of 1,330 feet. It is flanked on the west by a bank sixty feet high of grey mottled calcareous Niobrara shale, containing fragments of fish remains, and of a long thin-shelled *Inoceramus*, probably *Inoceramus problematicus*. These beds are, undoubtedly, a continuation of the upper harder beds seen on Rolling River. Close at hand are several springs strongly impregnated with sulphuretted hydrogen.

The shale is here overlaid by ten feet of unstratified glacial till with striated boulders.

Rolling River.

Returning now to Rolling River at a point S. 25° E. from the mouth of Tamarack Creek, where the bed of the stream has an eleva-

tion of 1,050 feet, a band of Dakota sandstone crops out from the bottom of a high bank, and crossing the stream, makes a succession of little cascades. This band consists of hard brown thick-bedded quartzose sandstone, massive or lamellar and often made up of small concretions about the size of peas, which are finely shown on many of the weathered surfaces. The surfaces of the slabs are often beautifully ripple marked, and on the edges show false-bedding in layers of about four inches in thickness. They contain *Lingula subspatulata*, *Modiola tenuisculpta*, *Lamna Manitobensis*, and pieces of carbonised or pyritised wood. The band of hard sandstone is overlaid by a bed of soft white sandstone or incoherent sand. The whole outcrop is a continuation of that seen opposite to it on the Swan River, and, lying below the shales of Niobrara-Benton age, clearly represents some of the beds of the Dakota group.

Below this outcrop the river was followed for a little more than a mile, and Cretaceous strata were not again seen, the banks being almost entirely covered with slides, but the same series doubtless occurs here, as has already been described on the Swan River.

In following the section of the rocks, as shown in the banks of Swan River and its tributaries, some of the more prominent surface features of the surrounding country have necessarily been omitted for the time, and it will now be necessary to mention some of the most important of these.

As was stated in the beginning of the report, Swan River flows in the bottom of a wide preglacial valley averaging about 1,200 feet in depth, cut through the Cretaceous plateau of the Duck and Porcupine mountains. The exact age of the valley is uncertain, but it is not improbable that it was largely formed during the period when the South Saskatchewan gravels were deposited in the west, and it would therefore be of Pliocene age. During the glacial period the valley was ascended by a lobe of the great glacier of the Winnipeg basin, and after the retirement of this glacier, most of the lower portion of the valley was occupied by a wide bay of Lake Agassiz, and is now generally covered with lacustrine or alluvial sands or clays.

An old cart trail, that has been used by the Hudson's Bay Company for the greater part of the present century, runs down the valley from Fort Pelly to the marsh at its mouth, keeping for most of the distance on the north side of the river. From the ford, ten miles north-east of Fort Pelly, the trail ascends the north side of the immediate valley of Swan River, and enters the "Five Mile Woods," a grove of spruce and poplar in which the soil is generally a dark clay, composed almost entirely of the subjacent Creta-

Delta plain.

ceous shale. East of this is a sandy plain, extending for about three miles and a half, and scored with old buffalo trails. In its eastern portion, the soil is a coarse sand, but towards the west it contains a large amount of gravel and its surface is strewn with boulders of reddish and greenish gneiss. This is clearly an old delta plain, and the conditions now existing are very similar to those found on the highest gravel plains on North Pine River, with which this corresponds more or less closely in altitude.

For the next mile and a half the trail winds through small poplar, growing on the gentle slope of the face of the old delta deposit, and then it crosses a gently undulating sandy plain for about six miles, beyond which is a belt of poplar in which the land falls about 100 feet. This poplar covered belt is locally known as the "Coast Ridge," and seems to represent the eroded face of another lacustral or delta deposit.

From the "Coast Ridge" to the "Square Plain" is a more or less open, and often sandy tract which extends up the south side of the river to beyond Bear's Head Creek. It was formed when the waters of Lake Agassiz washed the foot of the "Coast Ridge."

Square Plain.

Square Plain is a wide ridge of rounded water-worn gravel, rising about twenty-five feet above the swampy land to the east of it. In some places it is a quarter of a mile wide, and is composed of five distinct ridges separated by light hollows, representing slightly different stages of Lake Agassiz. North of Swan River it flattens out rapidly, and was not followed for more than three miles, while south of the river it sweeps round in a gentle curve to the east, for at least five miles, which was as far as it was followed in this direction. It is about 1,160 feet above the sea, as compared with the height of the bed of Rolling River at the crossing of the old Canadian Pacific Railway location, which is given by the railway survey as 1,180 feet. It is probably part of the same old shore line as the 1,151 feet ridge near the north-east angle of the Duck Mountain.

Low country.

For five miles north-east of the Square Plain the trail runs over level country consisting of belts of small poplar and low meadow land. At the above distance there is a light slope, on which an irregular ridge of barren sand dunes marks another shore line of the ancient lake.

For the rest of the distance to Oak Creek on the southern trail, extensive meadows are separated by little belts of poplar, while the northern trail runs through a forest of thick poplar for five miles, on a well rounded ridge of coarse gravel wooded with poplar and oak. This ridge appeared to be at about the same elevation as the Square Plain ridge, but the two were not definitely connected by survey.

Our camp was pitched for several days near the mouth of Oak Creek, Oak Creek. on the grassy bottom land by Swan River. The valley is sixty feet deep, and its sloping grassy banks descend in two beautiful terraces to the water. From here the writer made a trip with horses round and over the north-eastern point of Duck Mountain, his course being marked in a dotted line on the map.

Two miles below Oak Creek a distinct gravel ridge crosses the country, Great and for nine miles further in the same direction the "Great Meadows" Meadows. extend. They are wide stretches of rich flat land, covered with a thick growth of long grass, separated by narrow irregular belts covered with willow, and small, sometimes large, poplar. A forest of heavy poplar is then entered, and the trail is cut through it for six miles to the ford over Swan River, on the north-west side of which the Hudson's Bay Company used to have a store-house.

For the next six miles, the trail is on the south side of the river in heavy poplar, till a ford is reached, where the river has a sandy bed. The banks are here fifteen feet high, and consist of white or light yellow stratified alluvial sand, the north bank being steeply cut. About twenty-five paces back from this abrupt bank, and just to the east of the trail, is the site of an old trading post of the Hudson's Bay Old Fort, Company, which was moved in the early part of the century to its H.B.C. present position near the head of Shoal River. The country is very level, and the site is marked by six hollows or depressions, some of which were doubtless cellars, and two heaps of stones where chimneys formerly stood.

In a poplar grove between two and three miles further down the river, Old Fort, at the point indicated on the map, the old trading post of the North- N.W. C. west Company was said to have been situated, but the spot was not visited. This post, and in fact much of the Swan River valley, is described by Daniel Harmon in his Journal, as it was at the beginning of the present century, and it is also mentioned or described by David Thompson, Alexander McKenzie and others.

Below this old trading post the river is skirted by groves of poplar, elm, ash and ash-leaved maple, while flat low lying meadows extend towards the lake.

Returning to the streams that flow from Duck Mountain north- Bear's Head ward into Swan River, Bear's Head Creek, where crossed on a level Creek. plain three miles and a half from its mouth, was thirty feet wide, and ran over a bed of pebbles. It was not followed further, and its course is mapped from the survey of the western boundary of Manitoba.

Rolling River was examined from a point a short distance west of Rolling River. the 101st meridian, where it is about 2,250 feet above the sea.

It is here a small stream in a valley fifteen feet deep, with a spruce swamp on both sides. Its bed is covered with boulders, and its channel is much obstructed by beaver-dams.

Pleistocene deposits.

A short distance lower down it flows in a deep valley, the sides of which show some excellent sections of Pleistocene deposits.

One of these sections on the north bank is as follows:—

	ft. in.
Stratified gravel.....	10 ? 0
Unstratified till with striated pebbles.....	22 0
Stratified sandy clay, becoming almost a pure laminated clay at bottom, where it contains many plants and fresh-water shells such as <i>Taxus baccata</i> , <i>Elodea Canadensis</i> , <i>Vallisneria</i> ?, <i>Navicula lata</i> , <i>Encyonema prostratum</i> , <i>Denticula lauta</i> , <i>Licmophora</i> ?, <i>Cocconeis</i> ; <i>Lymnaea catascopium</i> ?, <i>Valvata tricarinata</i> and a keelless variety, <i>Amnicola porata</i> ?, <i>Planorbis parvus</i> ?, <i>P. bicarinatus</i> , <i>Pisidium abditum</i> and <i>Sphaerium striatinum</i>	6 0
Stratified gray sandy clay.....	20 0
Slightly sandy stratified clay, coloured dark brown with bituminous matter, and containing a few small bivalves	1 10
Plastic clay.....	5 0
Coarse stratified sand.....	12 0
Covered to water.....	12 0
	<hr/> 88 10

Heart Hill.

A quarter of a mile further down the river, near what is called "Heart Hill," a scarped bank 150 feet high shows a very similar section. The upper forty feet consist of unstratified till holding many pebbles and boulders of gneiss, quartzite, mica-schist, ironstone, &c., with scratched and polished pebbles and boulders of limestone. This is underlaid by seventy feet of stratified clay, sand and gravel, below which forty feet of the bank is covered with slides. The bed of the river is here about 1,800 feet above the sea, and, falling from the overlying till are many fragments of Niobrara shale, which have been shoved up by the glacier out of Swan River valley to the north.

Terrace.

For three-quarters of a mile below this interesting exposure, the valley has a well marked terrace forty feet above the bottom land, and then a moraine nearly half a mile wide crosses the valley. It consists of rounded hills covered with boulders separated by small inclosed basins. This moraine appears to have blocked the river for a time and permitted the formation of the terrace just mentioned, but the stream now flows in an irregular channel through it. The moraine was not followed beyond the valley, and its extent was therefore not determined, but it would appear to have been formed

Moraine.

near the close of the glacial period, by a small glacier flowing northward or westward from a névé on the summit of the Duck Mountain, after the great glacier of the Winnipeg basin had receded, and sufficient time had elapsed to allow for the excavation of the main valley of Rolling River.

Below the moraine the wide and often open valley continues westward for about three miles till it is joined by Round Lake Creek, also flowing in an old wide valley, one branch of which is said to be continuous with the upper valley of Shell River.

Here Rolling River turns northward and follows the bottom of a Deep valley, deep, thickly wooded valley to the northern face of Duck Mountain. At the mouth of this valley is an extensive gravel plain through which the river now winds in a channel from thirty to forty feet in depth. This plain is between 1,400 and 1,500 feet above the sea, or about Delta plain. the same height as the highest sand and gravel plain seen on Swan River, and the two were probably formed at the same period. The gravel underlying this one is often very coarse, and was washed out of the till when the deep valley of Rolling River was being rapidly excavated.

Below this plain the river has been for the most part already described in connection with the sections of the Cretaceous rocks. At its lowest crossing, a short distance above the mouth of Favell River, it flows through a level country in a valley a quarter of a mile wide and sixty feet deep. At the bottom of the bank are exposures of Dakota sandstone, while above it are beds of stratified lacustral sand and clay.

Favell River also rises on the summit of Duck Mountain. Its east Favell River. branch was not followed, but the source of the west branch is not far from the source of Rolling River, among rugged morainic hills covered with boulders and supporting only a scanty growth of small Banksian pine. It then enters a more even country wooded with spruce and poplar, and turning northward flows through a deep narrow valley to the northern face of the mountain. No sign of the underlying Cretaceous rocks were thus far seen, but where the bed of the river is about 1,800 feet above the sea a steep cliff shows at the top 100 feet of light gray unstratified till with striated pebbles and boulders, below which sixty feet are covered with slides.

From the foot of the mountain the river flows in a shallow channel across a heavily wooded plain for three miles, till it reaches the south side of Minitonas Hill, where it turns to the north-east and cuts through the hill, exposing some good sections of Niobrara shales.

Near its mouth, where the stream is about eight feet wide, it cuts through a well-marked gravel ridge with an altitude of about 1,030 feet

above the sea. This ridge was also followed across the east branch and for some distance into the country to the east.

East of Favell River the country was traversed on the dotted lines laid down on the map to the north-east point of Duck Mountain, and was found to be very level throughout, consisting, close to the mountain, of spruce and tamarack swamps, and further north of meadows and poplar forest.

PORCUPINE MOUNTAIN.

Position.

The Swan River valley is bounded to the north by the dark heavily wooded slopes of Porcupine Mountain, the streams from which, uniting to form Woody River, flow independently into the west side of Swan Lake. The most of this country was not personally examined but is mapped from sketches and triangulations made in the valley below, and from information received from native Indians or half-breeds. However, the trail from the mouth of Birch River to Kematch River was explored, and the valley of this stream was followed for a short distance.

Birch River.

Birch River flows into the west side of Swan Lake at the end of a long alluvial point, where it is thirty-five feet wide and five feet deep without current. Its banks are wooded with elm and oak, but a low meadow-land stretches away on both sides.

Bridle trail.

Starting at a point seven miles above the mouth of Birch River, the bridle trail strikes first westward and then southward across a level country without boulders, at first partly open, and afterwards wooded with large poplar. Ponds of saline (alkaline) water were occasionally found in some of the more open places, probably marking the line of outcrop of the Dakota sandstone at the base of the Cretaceous series. The trail crosses several small streams and then reaches an open ridge ten to twelve feet high and 500 wide running north and south. The ridge is a well rounded beach of Lake Agassiz with an approximate elevation of 1,125 feet above the sea, and is composed entirely of reddish quartz sand.

Kematch River.

Kematch River cuts a valley fifty feet deep through this ridge. The bed of the river is thirty feet wide, but towards the end of August the stream was only twelve feet wide and six inches deep. The bars are scattered with pebbles and cobbles of limestone, gneiss, ironstone and light gray Niobrara shale. At the foot of the bank is a low outcrop of hard bluish brown-weathering sandstone, doubtless belonging to the Dakota formation, overlaid by ten feet of dark slate-gray clay shale, breaking into minute flakes, and weathering to a soft mud.

These shales are very typical of the Benton formation and here represent its base.

From the ridge, the course of the river was followed on foot for two Escarpment miles to the face of the escarpment of Porcupine Mountain, where it flows out of a deep valley, from half to three-quarters of a mile in width. A number of low exposures of Benton shale may be seen during this distance, but the banks are generally composed of pebbles and small boulders, resting on a light gray till. The stream is overhung by gigantic balsam-poplars.

At the foot of the mountain the side of the valley is very steep and 140 feet high, but so overgrown with vegetation that the underlying rock could not be seen.

When returning to the bridle trail at the ridge, a course was taken Coast cliffs. south of the river. It first led down a steep slope sixty feet high on the face of the escarpment, then across a plain half a mile wide, and down another slope fifty feet high, at the foot of which was a flowing spring of clear water, tasting quite strongly of sulphuretted hydrogen. These escarpments represent ancient coast cliffs on the shore of Lake Agassiz, when the waters washed against their bases. The approximate elevations of these two shore lines would be about 1,270 and 1,200 feet above the sea respectively. Between the escarpment and the trail, much of the country is thickly wooded with large spruce, and another sand ridge is crossed with an elevation of 1,150 feet, on which is a grove of small oak trees. All this country is a famous hunting ground, and was everywhere beaten with fresh tracks of moose.

Further northward the face of the escarpment becomes higher and more abrupt, and the gorge from which Bell River flows can be clearly seen from Swan Lake as a deep notch in the brow of the dark green mountain.

*Mr. Dowling travelled on a footpath from the mouth of Birch River to the summit of the mountain beside this gap and gives the following description of the country passed over:—

"The trail leading from Swan Lake starts just west of the mouth of Birch River and follows a small creek coming from near the foot of the mountain. At the lake, a fringe of poplar about a mile wide is growing on the eastward slope, but this is succeeded by level land somewhat swampy, on which some spruce is occasionally seen. The rise for some distance, however, is very slight, and at seven miles from the lake the altitude is 1,000 feet above the sea, or 145 feet above Swan Lake. From there, however, after passing an apparently level mossy swamp, the rise is more abrupt, and beyond a patch of burnt

Bell River.

country on the surface of which are seen many large boulders of gneiss and limestone, the trail leads over several very distinct gravel ridges, forming an ascending series varying in elevation from 1,207 to 1,300 feet above the sea. These occupy a belt extending along the foot of the mountain, which, where crossed, is open, bearing only a few trees, principally jack pine (*Pinus Banksiana*). The trail deflects to the north, and leaving the gravel plain gains a somewhat level terrace, the steep face of which is strewn with boulders and the surface clothed with scrub poplar. The elevation of this terrace is about 1,400 feet above the sea, and in character it is very similar to the upper delta plain of the Swan River valley. Through it, the Bell River has cut a valley more than fifty feet deep, which seems to expose nothing but drift material.

The first exposure in this valley is above this delta plain, at an elevation of 1,450 feet above the sea. It is on the north side of the river, where a somewhat slidden hillside shows, to a height of thirty feet, a scarped face of dark gray clay shale. Thirty-five feet higher up the bank and on the south side of the river, is an outcrop of light gray hard siliceous clay shale, associated with a few dark nodules of iron-stone. These shales were found by Dr. Rüst to contain the following species of Radiolaria:—

Caryosphaera aequidistans. *Cenellipsis hexagonalis.* *Prunulum calococcus.* *Cyrtocalpis crassitestata.* *Dictyocephalus microstoma.* *Dictyocephalus macrostoma.* *Theocampe sphærocephala.* *Tricolocapsa salva.* *Tricolocapsa thoracica.* *Tricolocapsa Dowlingi.* *Tricolocapsa Selwyni.* *Dictyomitra Canadensis.* *Dictyomitra polypora.* *Dictyomitra multicostata.* *Stichocapsa Tyrrelli.* *Stichocapsa Dawsoni.*

Pleistocene deposits.

"Above this, no rock in place was seen, and on the upper part of the valley the immediate banks show a few escarpments of light clay containing sand, pebbles and small pieces of light gray shale. The whole is partly stratified. Above the valley on the edge of the escarpment of the mountain, dark clay mixed with shale is overlaid by sandy clay, probably a mantle of drift material covering the mountain. The valley viewed from the edge of the mountain is seen to be rough, small hills appear scattered in all directions. The surface is dotted with boulders, and the bed of the stream is a mass of boulders of all sizes."

The remainder of the eastern and the northern slopes of Porcupine Mountain were mapped from sketches and triangulations made on Swan Lake, Dawson Bay, Rice River, and Red Deer Lake and river, and the hydrography of the interior of its summit is dotted in from sketches obtained from John Beardy, Kematch, and Peter Moore, three Indians living on Shoal River. They also informed me that the summit is generally rough and uneven, probably morainic, and is wooded

with small spruce and Banksian pine, like many of the higher portions of Duck Mountain.

RED DEER RIVER.

North of Porcupine Mountain, lying between it and Pasquia Mountain, is another great valley similar to, but even more extensive than Swan River valley. It is almost entirely drained by Red Deer River, though Overflowing River occupies much the same position in this valley, that Woody River occupies in the Swan River valley.

At the mouth of Red Deer River, where it flows into Red Deer Lake, Indian camp. a small band of Indians make their headquarters. From these Indians horses were obtained, and a trail was explored from the south-west corner of the lake to the Smoking Tent, and thence westward to the mouth of the Etoimami River, whence another old trail was followed down the north bank of the river to its mouth. A brief description of this route will convey the best idea of the general character of the valley.

The trail leaves the lake just west of an old winter trading post of the Hudson's Bay Company, and runs for nine miles over almost level country through a forest of large poplar and spruce, with open grassy glades, to Swampy Creek, a tributary of Armitt River. This creek is ten feet wide, with a channel two feet deep, in which only a few inches of clear water was flowing in September, 1889. The banks are of sand and fine gravel. The creek flows from what appears to be a deep gap in the northern face of the mountain.

A mile and a half south-west of this creek the trail crosses a well-marked gravel ridge which rises ten feet above the surrounding land and has an elevation of 1,100 feet above the sea. For the next two miles and a quarter the course is through belts of spruce and poplar and open meadows to Armitt River, which is here a beautiful clear stream flowing in a channel five feet deep, in the bottom of a valley fifty feet deep, over a bed of rounded pebbles of gneiss, limestone and Niobrara shale.

200 yards below the crossing, on the west side of the river, is a scarped bank fifty feet high, showing at the top six feet of clay with striated pebbles, probably till. The rest of the bank is a series of slides, but on the face of one of the slides, close to the edge of the water, is twelve feet of dark gray fissile Benton shale, and a few yards further down the stream are many large masses of white Dakota sandstone, holding carbonized impressions of plants, &c. The height of the bed of the river at this point is 1,090 feet above the sea.

Porcupine
Mountain
trail.

Sandy plain. From here the trail ascends the west bank of the valley and strikes southward through open pine woods, on a sandy plain with a mean elevation of 1,180 feet above the sea, to a well rounded ridge, with an elevation of 1,230 feet above the sea, on which it turns to the west.

Between the trail crossing and the ridge, a distance of about one mile and three-quarters, the bottom of the valley was also followed, and some good exposures of the Cretaceous beds were measured.

Niobrara shale.

A mile and a quarter above the crossing a steep cliff rises on the east bank of the river, showing at the top eight feet of light gray till with limestone pebbles, underlaid by thirty-two feet of dark gray soft fissile Cretaceous clay shale, in which there is a narrow band of soft white clay.

A third of a mile further up the river, and a short distance below the main gravel ridge followed by the trail, is a high bank of dark shale. In this bank, ten feet above the water, is a thin nodular band of light gray mottled calcareous Niobrara shale, containing many foraminifera, with prisms of *Inoceramus* and fragments of fish skeletons.

At the ridge, the river is beginning to be much obstructed with boulders, and the banks southward to the mountain seem to be generally low, while the surrounding country is chiefly timbered with poplar, and is probably crossed by other low ridges.

Gravel ridge. The ridge followed is composed of sand and fine gravel, is generally raised from six to ten feet above the surrounding wooded or marshy country, and is wooded with a thin growth of small aspen. The trail runs along its summit for ten miles, in which distance it is cut across by several brooks, which do not expose sections of any particular interest. At Bushy Creek the trail forks, one branch turning northward towards Red Deer River, while the other branch, which was the one followed, turns southward across a level country to another wooded ridge twenty feet higher than the last, and then westward along this ridge for more than a mile to Smoking Tent Creek, which flows in a valley 300 feet wide and twenty-five feet deep. Its bed is twenty-five feet wide, and covered with rounded gravel. Half a mile west of the ford and close to where the creek first strikes the ridge, is a small open prairie locally known to the Indians as the Smoking Tent "Smoking Tent," where they are accustomed to camp from time to time. The point is close to the extreme western limit of the area covered by the accompanying map, and from it a direct trail is stated to run to Fort Pelly.

West of this place, the trail, back to the upper Red Deer River, continues on the ridge for two-thirds of a mile and then turns to the lower ridge, which it follows for between seven and eight miles,

to the west end of a long meadow which skirts its upper side. The trail then turns southward for more than a mile to a small open prairie, on another ridge which is clearly the continuation of the Smoking Tent beach. This ridge is generally composed of fine gravel, is about 125 paces wide, and is raised ten feet above the surrounding country. It was followed for between six and seven miles, as it curves gently towards the north, till about a mile past a point where it is joined by a good pack trail from Fort Pelly, it becomes indefinite and merges into a wide sandy plain dotted with sand dunes lightly wooded with Bank-sian pine. Here we turned north-eastward, and crossing the sandy plain for a mile and a third, reached the Red Deer River in a valley thirty feet in depth.

Extensive delta plain.

The channel is 250 feet wide, but the water at the time was not half that width, and was flowing over and through a bed of large boulders of gneiss and limestone. The banks at the bottom are composed of light gray unstratified till, holding pebbles and many large boulders similar to those in the river, while above is a reddish stratified sand. The sandy plain was clearly formed by a river which flowed into Lake Agassiz when its waters stood at the height of the Smoking Tent beach, but its exact correspondence in age to other delta plains on the west side of Lake Agassiz has not yet been determined.

Two miles further upstream Fir River (O-kik-kan-tag Sibi) joins the Fir River. Red Deer River from the north, draining the southern face of the Pasquia Mountain. It is thirty feet wide, with water from bank to bank, and its bed, like that of the main river, is covered with boulders. Its mouth is fifteen miles west of the accompanying map, in north latitude $52^{\circ} 50'$ and approximate west longitude $102^{\circ} 24''$.

Just below it the bank of the river is forty-five feet in height, and consists at the top of twelve feet of light red horizontally stratified sand, underlaid by a few feet of gravel. The rest of the bank is covered with debris but springs are flowing from its foot, and it is therefore probable that it is in great part composed of stratified deposits.

A short distance further down stream is the mouth of the North North Etoi-mami or Shallow River (Ka-pa-kwa Sibi), which was ascended by Professor Macoun in his trip from Red Deer to Swan River in 1881. At its mouth it is about 100 feet wide, with a bed of large boulders, over which little or no water was flowing in September, 1889. A cliff of light gray till twelve feet in height overhangs its western bank, and on a magnetic bearing N. 55° E. from this cliff, on the bottom land on the north side of Red Deer River, are the chimneys and cellars of two old houses that were formerly occupied as a trading post by the North-west or Hudson's Bay Company.

Trail north of Red Deer River. From the mouth of Fir River a bridle trail, often very obscure, was followed down the north side of Red Deer River to within seven miles of its mouth.

Boulder of Dakota sand-stone.

The first mile is across a sandy plain wooded with Banksian pine, and the next six miles are over level or gently sloping country wooded with poplar or studded with small dead spruce. At the end of this distance, near the mouth of Spring Creek, the river is moderately deep, with an easy current, and the banks are composed of stratified sand or till. A large boulder of white Dakota sandstone is here lying in the bed of the stream. Its surface is pitted with holes caused by the decay of nodules of pyrites and in them the Indians put small offerings of bullets, shot, &c. The boulder is twenty-five feet long, sixteen feet wide, and rises three feet above the surface of the water. Its angles are well rounded off, and its upper surface is clearly marked by a number of elongated dints, often running into irregularly disrupted gouges, parallel to the river, and evidently made by the spring ice or stones, &c., borne along by it. But these markings are quite distinct from a series of long continuous nearly parallel gouges or scratches, which cover the whole upper surface of the boulder, running parallel to its greatest length, and which have been quite clearly formed under the influence of glacier ice.

The river at this point is about 1,100 feet above the sea, and the boulder has been carried up the valley, by a westward flowing lobe of the great glacier of the Winnipeg basin, from the beds of the Dakota sandstone which outcrop twenty miles further to the north-east, and at from 100 to 200 feet lower level.

From Spring Creek to opposite the mouth of Smoking Tent Creek, close to the western edge of the map, the trail keeps near the river, often on its alluvial flats, and the banks were found to consist entirely of superficial stratified sand, &c., or glacial till.

Ash-leaved maple.

Opposite Smoking Tent Creek is a fine grove of large ash-leaved maple, close to which is a sandy plain by the river, where the Indians camp when they come in the spring to make maple sugar. Leaf Lake (Was-ki-té-poo Sakàhigan) on Overflowing River, was stated by an Indian who accompanied me, to lie immediately to the northward, and sufficiently close that in favourable weather in winter, a gun fired on the lake could be heard here.

Banks of till. For nine miles below the sugar bush the river continues to flow in a north-easterly direction, between banks overhung with elm and maple, while a poplar forest stretches away on either side. The banks generally consist of till with boulders, often overlaid by stratified alluvial clay.

The river then bends to the east, and at the bottom of the bank Dakota sandstone. light green Dakota sandstone appears for the first time. The section here exposed is as follows :—

	ft. in.
Unstratified till in the form of light gray hard sandy clay, with many striated pebbles and small boulders of gneiss and limestone, with a few of iron pyrites	17 0
Covered.....	22 0
Soft green clayey sand.....	1 0
Horizontal green Dakota sandstone.....	1 6
	— —
	41 6

This sandstone is very similar to that seen at the crossing of Armitt River, but here it was found to contain some pyritised wood, with teeth and bones of fishes, and a small species of *Lingula*.

Below this sandstone the river turns to the south, and a deep abandoned valley continues to the east, which is entered again by the river two miles further down. The valley is here seventy feet deep, and the banks consist chiefly of light gray till. For a mile and a half further eastward the trail runs across a sandy plain dotted with sand dunes, and at the end of the distance the bank of the river shows at the bottom five feet of soft brown or red Dakota sandstone, in places clearly false-bedded. It includes some thin bands of black clay, as well as many pebbles? of a clayey sand holding remains of plants. This is overlaid by fourteen feet of soft white evenly-bedded sandstone, and this again by light gray till with striated boulders.

For the next three miles the valley is deep, and the white Dakota sandstone outcrops here and there along its sides.

To within half a mile of the lowest outcrop of this sandstone, Mr. Dowling made a micrometer and compass survey of the river from the lake upwards in 1888, but there further ascent of the river with canoes became impracticable at the then stage of the water.

From this point the trail descends through woods of small poplar Thick woods. into a grove of beautiful tall spruce, and then through poplar, elm and maple to the river at its most northerly point, where its bank rises in an abrupt cliff of till thirty feet high. Our course then passed through woods of elm, poplar, maple and willows to the next bend of the river, where there is a patch of ground that had clearly been tilled long ago, and is now overgrown with golden rod, beyond which the trail follows the bank of the river on a beautiful grassy plain to the site of the Old Fort of the North-west Company.

This fort had a pleasing situation on a level alluvial plain, in front of Old Fort, which the river, with a width of 250 feet, flows in a channel fifteen feet N.-W. C.

Old Fort,
N.-W. Co.

in depth. Just on top of the steep bank, and almost ready to be carried away by the first flood, is a heap of earth and stones, representing a chimney of one of the old houses, while all the others seem to have been already carried away. Several small depressions in the vicinity may, however, represent old cellars or holes in which potatoes were stored.

Standing with his face towards the river the writer looked across to a lovely forest of elm and maple, just tinted with brilliant autumn colours, while to the right were groves of maple and willow, and to the left was a forest of poplar pinnacled with spires of dark green spruce.

At the beginning of the present century this place was an important trading establishment of the North-west Company, being mentioned by Sir Alexander Mackenzie as one of the three chief trading posts of the Lake Manitoba district. From it a cart trail is locally reported to have led up the north side of the river to the western plains, but no trace of such a trail can now be seen.

A mile and a half below this old fort the trail crosses the river, where a fine grove of large ash-leaved maples is growing near the southern bank. A mile further down stream the remains of an old fort of the Hudson Bay Company are to be seen within a heavy poplar forest.

Old Fort,
H. B. Co.

For the rest of the distance to its mouth, the banks of the river are low, and stretch back to extensive meadows covered with rank grass.

DUCK MOUNTAIN.

Position and
extent.

Duck Mountain is an elevated table land or extended ridge rising in some places to 1,900 feet above Lake Winnipeg or 2,600 feet above the sea. It is bounded on the north by a wide sloping valley, down the centre of which Swan River flows into Swan Lake, and thence by Shoal River into Lake Winnipegosis. To the north of this valley the Porcupine Mountain rises apparently to a height equal to that of Duck Mountain, while in the middle of the valley, Thunder or Bird Hill rises 500 feet above the plain at its base, having been left as an outlier by the denuding agencies that carved out the valley from the once continuous plateau. Towards the east the mountain is bounded by the Manitoba escarpment sloping down into a wide depression, the bottom of which is occupied by Lakes Winnipeg, Winnipegosis, Manitoba and a number of small surrounding lakes. Towards the west the mountain slopes off much more gradually to the valley of the Assini-

boine River, the head of which at Fort Pelly is 650 feet above the level of Lake Winnipeg. Towards the south it merges into the Riding Mountain, being separated from it merely by the valley of Short Creek, which towards the east opens out into the wide funnel-shaped valley drained by Valley River.

The eastern face of the mountain is drained by several small streams Drainage. that flow into Lakes Winnipegos and Dauphin, most of which, however, rise below the summit of the escarpment. A belt along the north side of the mountain is drained by streams that flow northward into Swan River. The greater portion of the area of the surface, however, is unwatered by the Valley and Shell rivers, which flow parallel to each other southward for a considerable distance and then diverge, one to flow eastward into Dauphin Lake, and the other, after flowing westward for six miles, to again turn southward to join the Assiniboine River. West of Shell River several small streams drain the country south-westward into the Assiniboine River. Very few of the streams show signs of the underlying Cretaceous rocks, the country being generally thickly covered with drift deposits, but it is quite probable that in some cases the valleys of the streams are cut down to a much greater depth than the thickness of this superficial covering of drift.

East of Shell River the Duck Mountain is generally very rough Rough hills. and uneven, consisting of ridges, and apparently irregular areas, of drift hills thickly covered with gneissoid boulders, often bearing a scanty growth of Banksian pine, between which are extensive areas of comparatively level marshy land densely overgrown with spruce and tamarack. The southern portion of this district is drained southward into Valley River, part of the central portion westward into Shell River, while the northern portion is drained either northward into the Rolling and Favell rivers or eastward into the Duck and Pine rivers.

The source of Valley River was not visited, but Indians who were hunting in the vicinity reported that it rose in Singoosh or Weasel Head of Valley River. Lake and flowed south-westward to Angling Lakes. Another small branch of this stream was, however, found to rise in a wide swampy level country covered with spruce and tamarack, and probably underlaid by alluvial or lake deposits. The small creek, flowing from this swampy area towards the south-west, soon cuts through a ridge of irregularly rounded hills running in a north-westerly and south-easterly direction. These hills are thickly overstrewn with boulders and separated by basin-shaped depressions, and have all the appearance of being an old moraine. After flowing through this morainic ridge, the creek enters a wide valley. The bottom is swampy and covered with willow or spruce. The south side is a continuation of the high ridge that extends east-

ward to Manitowachi, while the north side rises in beautiful gravel terraces to what appears to be an alluvial or flood-plain of considerable extent. Continuing towards the south-west for two miles, and then turning north-westward for about three miles, this small creek joins the main stream of Valley River.

South of the river is a rough morainic tract rather thickly timbered with spruce, birch and poplar. West of this morainic area a more or less level district stretches for several miles, in the bottom of which lie several small lakes known to the Indians as the Angling Lakes. Near these are a number of well built log houses in which Côté and his band of Saulteux live during the winter season, while hunting and trapping in the neighbouring forests.

Angling Lakes.

Indian cart-trail.

Following the cart-trail westward from these lakes an area of rich meadow land is passed over, consisting of wide swails separated by long low ridges. The surface consists of sand and rounded water-worn gravel, the latter chiefly composing the low ridges on one of which the Indian houses are built.

Wide valley.

About two miles west of the village the trail crosses a ridge of rounded knob-like morainic hills scattered over with gneissoid boulders. Beyond this again is a lightly rolling country generally thickly timbered with large aspen and dotted here and there with small marshes. In the middle of this district the trail crosses the north end of a wide valley, the bottom and sides of which are covered with sand and gravel, no boulders being seen on the surface. The south side is open and grassy and rises in regular terraces, the surface of which in many places, however, are not at all level, but show low knobs and basin-shaped depressions, very much like the usual morainic contours; but it seems not impossible that the depressions may be caused by the unequal carrying away of the finer particles from among the gravel by underground drainage, and the consequent irregular sagging of the surface.

Valleys of the Champlain or Terrace Epoch.

Shell River valley.

Extent.

The most noticeable of these valleys is that of Shell River, its extreme northern portion being occupied by Rolling River. This valley runs in an almost due north and south direction through the centre of Duck Mountain. At the northern end it opens on the abrupt escarpment of the mountain into the wide valley of the Swan River and its tributaries, and at its southern end joins the valley of the Assiniboine. Its length measured in a straight line from one end to the other is sixty-seven miles, but counting its windings its total

length is ninety-five miles. It has an average width from brim to brim of three-quarters of a mile or a little more, and its depth ranges from 100 feet at the mouth of the east branch to 365 feet at the trail crossing at Asessippi.

As is shown by the present course of Shell River, the valley has slope. a general slope towards the south. The height of the river flats at the mouth of the east branch is 2,050 feet above tide, and of the flats at Asessippi 1,450 feet above tide, giving a fall of 600 feet in seventy-five miles, or an average fall of eight feet to the mile. This fall is pretty evenly distributed throughout the whole of the above distance, though towards the mouth it is a little steeper than elsewhere. The north end of the valley for three miles is occupied by Rolling River, but, unlike that further south, is here thickly wooded with spruce and poplar, and it is much more difficult to see its salient features. About thirteen miles of the course of the valley was not followed, but looking up the north branch of Shell River it was seen to continue onward for several miles till a light bend cut off the view, and the bottom was filled from bank to bank by a deep marsh, in which the stream appeared to take its rise. Looking from Rolling River, it appears as a deep valley, down which flows a small tributary. A half-breed who was with me, and who was acquainted with the country, stated that this valley is a continuation of that of Shell River, and in it there is a marshy watershed.

Beginning in latitude $51^{\circ} 43'$, a short distance above the confluence of the east branch, the valley is a mile wide and largely occupied by a beautiful even prairie lying on the east side of the river, and sloping very lightly towards the west. This prairie is underlaid by small rounded water-worn gravel, and represents a flood-plain of the ancient stream. Proceeding southward to the mouth of the east branch, which flows in a narrow lateral valley, the main valley is a mile wide, with an alluvial flat on the east side which is underlaid by a sandy loam, and partly covered with willows, while on the west side of the river a low sparsely wooded terrace half a mile in width extends along the foot of the bank. The Indians allege that at this point, huge bones were found at the bottom of a land-slide and were brought to the officer in charge at Fort Pelly, by whom they were forwarded to England. Hon. W. J. Christie, of Brockville, Ont., who was in charge of Fort Pelly at the time, informs me that the bones were shoulder blades, and that in 1853, some years after the first bones were brought in, he visited the place, "and examined the spot carefully where the blade was taken out of the river at low water. A land-slip had occurred from the bank and carried the bones into the river. I found from cross-questioning my

Bones of
Mastodon.

guide, that the Indians had collected the bones, and burnt them on the bank, from superstition, and buried what would not burn. I examined the spot where they had buried the bones, but what remained crumbled to pieces when touched."

These bones, consisting of a pair of mutilated scapulae of a fossil elephant, were submitted to Sir John Richardson for examination. He first described them as belonging to a new species which he named *Elephas Rupertianus*, but afterwards identified them as belonging probably to *Mastodon giganteus*. His descriptions are not generally known, and will be of interest here.

Description
by Sir John
Richardson.

"The scapulae are right and left, and, being of the same size, were most likely members of the same individual. The broad ends of the blade in both are wanting, and most of the spinal ridge. On comparing what remains with scapulae from Eschscholtz Bay, and with the homologous bone of the *Elephas primigenius* in the British Museum, I find that these fragments differ in possessing a well-marked depression between the humeral end of the ridge and the anconal edge of the bone. This depression is $4\frac{1}{2}$ inches long, and has an abrupt edge, upwards of an inch deep, next the spinal ridge, but gradually passes into the flat bone in other directions.

The length of the glenoid cavity is.....	9·1 inches.
Its breadth.....	5·5
The space between the depression and the acromial edge of the bone where narrowest is.....	4·0
Length of the largest fragment.....	17·5

"The probability is that the Swan River (Swan River district) bones belonged to the *Mastodon giganteus*, and that the range of that species must be extended northward in Rupert's Land to the fifty-second parallel of latitude."*

For four miles below the mouth of the east branch the valley appears to be less definite, and being more or less wooded its characteristics are more difficult to make out in a running examination.

Valley
deepens.

Turning south-south-eastward from the point where a pack-trail from Coté's Reserve crosses the river, the valley is moderately straight for seven miles, and its banks quickly increase to 200 feet in height. On the west side of the valley a terrace rises to the height of 100 feet, but its eastern face, instead of being abrupt, is sloping and grassy or dotted with a few scattered Banksian pines, the top of the terrace is covered

*The Zoology (of the) Voyage of H.M.S. Herald; Vertebrals, including Fossil Mammals, by Sir John Richardson, pp. 101-102 and 141-142, 4to, London, 1854.

Also Proc. Bost. Soc. Nat. Hist., Vol. 5, (1854) p. 82.

And Am. Jour. Sci., Vol. 19 (1855) pp. 131-2.

with spruce and poplar, the most of which has, however, been lately destroyed by fire.

Turning now towards the south-west for seven miles the valley shows a beautiful series of terraces reaching up on either side to near the tops of the banks, those on the north side being grassy and open, while those on the south side are covered with poplar. Close to the river the bottom of the valley is often wooded with spruce and tamarack. These terraces consist of water-worn gravel, the brows of the higher ones being scattered with boulders of gneiss. The lowest one is generally wide, and smooth, and reaches to near the bank of the stream.

At the end of the above distance, the river sweeps round to the left and for ten miles flows in a south-easterly direction, at right angles to the course that it has just been following. A high gravel terrace runs round the outer side of the bend for a considerable distance, and before it is entirely cut away, it reappears as a beautiful wide open bench on the opposite side of the river. Throughout the whole of the distance that the river keeps this south-easterly course the banks are very regular, being composed entirely of high terraces, the upper one of which extends back a considerable distance to the higher land behind. Near the southern end of this straight stretch slight exposures of clay are seen in the banks on opposite sides of the valley, that on the east side, which was more closely examined, showing six feet of unstratified light gray sandy clay holding striated pebbles, overlaid by three feet of stratified water-worn gravel. Also in a gully at the bend of the stream a Till and slide has very imperfectly exposed about thirty feet of light gray and yellowish clay and sand, the upper part being a fine slate gray clay, while below it is a yellowish slightly clayey sand. The face of the bank is covered with slidden pebbles, some almost round and others very irregular, of limestone much striated, quartzite occasionally striated, gneiss and ironstone.

Now turning at right angles the valley continues for seven miles in a south-westerly direction. It is wide and open, bending in long sweeping curves. The inner sides of the curves rise in many grass-covered gravel terraces to 120 feet above the river. The banks are moderately well defined, scored by small lateral gulleys, but are nowhere cut into rounded hills separated by deep basin-shaped depressions, as they are below the next bend. The brows and often the tops of the higher terraces are generally strewn with gneissoid boulders.

At the end of the course towards the south-west, the river again bends round to the left, and for eleven miles flows in a general direction S. 30° E. The character of the valley now suddenly changes. It is uneven sometimes as much as two miles wide, and its banks are very irregular

and from 200 to 300 feet high. At first, gravel flats and low terraces continue down the centre of the valley, and the sides are rough, or with a skirt of rough rounded hills under the brow of the main bank. In some places wide terraces stretch out towards the river, and deep "kettle-holes" are found in the otherwise level bench, beyond which again may be a ridge of rounded hills thickly covered with gneissoid boulders. Near the crossing of the north line of Township 26, the sides of the valley are fringed with these rounded hills. On the east side, the river cuts into one of them, and though the exposure is very largely hidden by slides, yet at the height of sixty feet above the water there can be seen eight feet of light yellowish-gray unstratified slightly sandy clay, holding pebbles of gneiss and limestone, the latter of which are all plainly striated. Springs of water are running from the bottom of the bank, and as the above described boulder-clay is seldom sufficiently porous to allow water to flow through it, it is probable that the Cretaceous shales may here be found under the boulder-clay and above the level of the bottom of the valley.

Moraine.

For a mile and a half further down the valley the river flows through a wide gravel plain, and then the rounded drift hills, thickly strewn with boulders, close in from both sides and choke the valley, the river cutting a comparatively narrow channel through them. Below this barrier the drift hills are confined to the east side of the river, and from their base a wide alluvial plain stretches across the valley, above which, on the west side, gravel terraces very soon begin to rise. The hilly country extends for a considerable distance back from the river towards the east. The river cuts into the side of one of the hills, and shows it to be composed of unstratified till, against which on both sides stratified river gravels are lying horizontally. This hilly ridge which has thus been seen to run very obliquely across the deep valley of Shell River would seem to be an old moraine left by the continental glacier in one of the later glacial periods, or by a lobe of it which occupied the valley of the Assiniboine.

From the south end of this course of the river, a narrow valley with its bottom occupied by small lakes or marshes, continues southward but drains northward into Shell River.

Short Creek.

Another deep narrow valley also turns off to the east, in which Short Creek begins to flow eastward to Valley River. It is at first clearly defined, with steep banks 150 feet high and about three-eighths of a mile apart on the top. The bottom is a marshy flat. Deep narrow gullies join it from both sides, out of one of which the creek takes its rise. A short distance west of this gully the sides of the valley have been washed down causing a dam which forms the watershed between

the waters flowing to the east and to the west. The lower part of the valley of Short Creek is wider and much more sloping, with banks cut into rounded knolls, and generally covered with gneissoid boulders. The difference between the two parts of the valley is very abrupt and striking, showing the eastern portion to be a much older drainage channel than the steep narrow portion further west. The newer part of the valley has probably been excavated by the waters of the upper Shell River, which found their way along the east side of the morainic ridge just described, and thence flowed eastward down Short Creek into the west side of Lake Agassiz.

Turning westward from the point where these valleys join, Shell River flows almost due west for five miles, then south seventeen miles, and then north-west four miles to its mouth. The valley throughout this distance maintains very much the same character as before, except that it is generally wider and becomes much deeper towards its mouth. High terraces rise on either side, the upper one of which on the north side extends back one to two miles before the main bank is reached. At the bend towards the south the valley is two miles wide and on the inner side of the curve, gravel terraces rise to a height of 140 feet above the river. The brows of these terraces are, as before, often thickly strewn with large gneissoid boulders. About section 15, township 24, the valley is again more than a mile and a half wide and the east bank rises in five well-defined terraces, which are respectively about 30, 75, 125, 170 and 180 feet above the river. Above the top of these, the bank again rises 120 feet to the level of the surrounding country. In section 34, township 25, the highest gravel bench on the south-east side of the valley is 100 feet above the river and is thickly strewn with boulders. It differs from the terraces in most parts of the valley, however, in not having a level surface. Its middle line is the highest, and from this line it declines from ten to fifteen feet towards each side, in the one direction to the brow of the terrace, from which it descends sharply to the bench below, and in the opposite direction to abut sharply against the side of the valley, which rises high above it. This latter depression probably indicates an ancient channel of the river when the bottom of the valley was at the height of this terrace.

At Asessippi, where the river finally bends towards the north-Asessippi. west to join the Assiniboine, several well-defined terraces occupy the north side of the valley, the highest of which is 185 feet above the level of the river at the mill-dams. The top of the bank of the valley on this side is 250 feet high, north of which, for several miles is a small area between the Shell and Assiniboine Rivers, covered

Lower portion
of river.

with alluvial sandy deposits, indicating the existence of a former lake at the junction of these two streams.

The south bank of the valley at Asessippi is more than 100 feet higher than the north bank, is very steep and largely covered with land-slides. As far as can be seen, it consists of unstratified glacial till, but it is not improbable that the bottom of the bank, if uncovered, would be found to be composed of Cretaceous shales.

A description has thus been given, in greater or less detail, of the principal one of these old glacial valleys cutting through the Duck Mountain. Between the Shell River and the Assiniboine, however, there is a plexus of similar valleys which was crossed in several places. It is now drained by the Little Boggy and Big Boggy creeks and a small brook flowing into Shell River.

Big Boggy Creek.

Big Boggy Creek, at the crossing of the Fort Pelly trail, is a small stream twelve feet wide and one foot deep, with a bed of rounded pebbles. Its valley is 180 feet deep. The north side is rough and uneven, its character being in all probability determined both by former terraces and old land-slides. On the south side a sandy flood-plain forms the top of the bank and lies only a few feet below the surrounding more irregular country. The next point where this valley was seen was in section 29, township 28, on the cart-trail from Côte's Reserve to Angling Lakes. The creek is here four feet wide and two feet deep, and flows through a very swampy bottom. The banks of the valley are 145 feet high and very abrupt. On the eastern side of the valley is a beautiful grassy flood-plain or terrace, underlaid by water-worn gravel, which stretches a long distance towards the south, and half a mile back from the brink of the valley. To the west the country is scattered over with boulders and is underlaid by a light coloured fine silt including pebbles. The boulders are especially numerous on the tops of the pointed knolls that lie along the face and summit of the escarpment which faces towards the west and overlooks the apparently level plain of the Assiniboine below. From the point where the Angling Lakes trail leaves the river, the valley continues in a northerly direction, and our guide stated that it united with that of Little Boggy Creek.

Little Boggy Creek.

At the crossing of the Port Pelly trail, Little Boggy Creek is a small stream fifteen feet wide and one foot and a half deep. It is thus seen to be much larger than the Big Boggy, the first adjectives referring rather to the amount of swamp on the banks of these little streams than to the size of the streams themselves. Two and a half miles east of the trail crossing, Little Boggy Creek flows from a wide valley about 200 feet deep at its mouth. Seven miles further

in a north-north-easterly direction, at the crossing of the western boundary of Manitoba, it is stated by J. P. O'Hanly to be 260 feet deep, and my half-breed guide also stated that it then turned south-eastward and joined a similar deep valley that carries a small stream into Shell River in Lat. $51^{\circ} 31'$. From the western mouth of the valley the Little Boggy now sweeps round towards the north, but the ancient stream would appear to have turned southward into a deep swampy valley, through which it found its way to the Assiniboine.

ASSINIBOINE RIVER.

The Assiniboine River rises near the head waters of Red Deer Source. River, and flowing south-eastward, crosses the Second Initial Meridian close to Fort Pelly.

From here it was descended in a canoe by the writer in June, 1890, but as its valley has already been described by S. J. Dawson, Prof. J. Macoun, Dr. R. Bell, and others, it will not be necessary to mention anything but its geology, and a few points in reference to its history as a trade route.

Our boat, a small Osgoode canvas canoe, was put in the river in Descent in June, 1890, opposite Fort Pelly, and the river was descended to Portage la Prairie, thirty days being occupied on the trip.

Fort Pelly is situated on rising sandy ground on the east side of the Fort Pelly. river, and is a large well-built fort protected by a high fence or wall of sawn planks. Over the heavy gate in front is a stout bastion, from the top of which a magnificent view can be had of the surrounding country. This fort was built by the Honourable W. J. Christie, Chief Factor of the Hudson's Bay Company, in 1856-57, while previous to that date the fort had stood on lower land 500 yards distant in a direction N. 65° W., where there is a low sandy ridge rising six feet above the general level of the bottom of the valley. The site of the old fort is now marked by ten pits in three rows, and a few small boulders.

Three miles in a direct line below Fort Pelly the west bank of the Pierre shales. river is twenty-five feet high, and is thickly strewn with nodules of iron-stone and boulders of limestone and gneiss. The upper part of the bank is a dark gray till, below which is two feet of Lower Pierre (Millwood) shales, consisting of a brownish-gray soft clay shale, weathering into a soft light gray clay. This shale contains a number of light gray nodules of ferruginous limestone, but no traces of fossils could be found.

At a fish-weir, a quarter of a mile further down the stream, a large spherical or hemispherical nodule of Dakota sandstone, like those out-

Boulder of
Dakota sand-
stone.

Boulder of
Dakota sand-
stone.

cropping on Kettle Hill south of Swan Lake, is lying at the foot of the bank, having evidently fallen out of the till. The nearest point at which the Dakota sandstone outcrops is in the banks of Swan River not far from the mouth of Tamarack Creek, forty-two miles distant in a direction N. 50° E. and at an elevation of 1,025 feet above the sea. This formation is believed not to outcrop at a higher elevation than 1,125 feet above the sea anywhere on the whole face of the Manitoba escarpment. The place where the boulder is now lying has an approximate elevation of 1,475 feet or 450 feet above the nearest bed of parent rock, or 350 feet above any outcrop of the rock, for there is every reason to suppose that there are no exposures of the Dakota formation to the west of Fort Pelly until the disturbed strata in the vicinity of the Rocky Mountains are reached.

Its journey.

The boulder has therefore been carried up the Swan River valley in a south-westerly direction, for at least forty-two miles, by the Swan River lobe of the Winnipeg glacier, rising in the distance travelled at least 350 feet.

Alluvial
banks.

From this point to the mouth of White Sand River the banks are generally stratified alluvial sand or clay, with here and there a slight exposure of Lower Pierre shales holding ironstone nodules. The river begins with a width of about fifty feet and a swift current, with sandy points stretching into the stream on the concave sides of the bends, and the channel much obstructed by snags and boulders, but it gradually increases to a width of 120 feet, becomes more sluggish, and the inner sides of the bends are rounded and covered with long-leaved willow.

White Sand
River.

White Sand Creek is a stream thirty feet wide and three feet deep, with a perceptible current to its mouth.

From White Sand to Little Boggy Creek the river is generally deep with a sluggish current, and with a few slight rapids at the bends. The banks of the channel are ten to fifteen feet high, of alluvial clay, while the sloping banks of the valley are thinly scattered with boulders.

High terrace.

Little Boggy Creek, about fifteen feet wide, flows through a wide alluvial meadow to its mouth. Above this meadow it flows through a moderately level plain, with a mean elevation of 1,540 feet, rising gently to the foot of a terrace along the base of Duck Mountain. North of Little Boggy Creek this latter terrace is a mile and a half wide, extends for a long distance to the north, and has a mean elevation of 1,700 feet above the sea. To the eastward, Duck Mountain rises as a long undulating slope, the nearest parts of which are only lightly wooded.

Crow's Stand.

From the upper terrace an elongated hill or ridge, known as the "Crow's Stand," rises abruptly to a height of 120 feet. This hill is

lenticular in shape and trends N. 25° W. and S. 25° E. Its north-west end and both sides are very steep, and its top is rounded, but may be said to be fifty feet wide. Its highest point is close to its north-west end, whence it slopes very gradually S. 25° E. for half a mile and then dips more rapidly to the general level. There are no cuts or breaks in the surface of this hill to show its true character, but its summit is sandy, and scattered with large boulders of gneiss and dolomite, while its sides are gravelly and its whole surface is too barren to grow any timber. It has therefore every appearance of being a drumlin or ridge ^{Drumlin.} of sand, gravel and boulders formed beneath the ice when this whole valley, stretching westward from the foot of the Duck Mountain, was filled with a glacier.

The terraces were then formed on the shore of the lake, elsewhere called Lake Assiniboine, that occupied this basin when the glacier withdrew from it. Throughout the whole of the way from Little Boggy Creek to Fort Pelly the cart-trail is on the bed of this ancient lake. ^{Ancient lake.}

Below Little Boggy Creek the valley of the Assiniboine River becomes deeper and more sharply defined, and its sides are generally wooded, while the bottom-land is either wooded or open. Scarped banks are occasionally seen, composed of Pierre shale with ironstone nodules, or gray till. Several spring creeks join the river from the east in this stretch.

About the middle of the east side of the S.W. $\frac{1}{4}$ section of Section 14, Township 28, Range 31, are the ruins of an old trading post of the North-west Company. It stood in the bottom of the valley 500 paces east of the river, and fifty paces from the foot of a wooded bank, at the mouth of a dry ravine, on lightly sloping land thirty-five feet above the river. The post was built by Mr. Cuthbert Grant, one of the traders of the North-west Company, previous to the close of the year 1793, and for many years did a large trade in beaver and otter.* ^{Cuthbert Grant's house.}

The fort or trading post appears to have covered about a quarter of an acre, in which area are six pits that doubtless represent the old cellars. Beside one of the largest is a heap of boulders that were formerly built into the fireplace of the largest of the houses.

A mile to the south of the old fort, the west bank of the valley is 240 Sandy banks. feet high, on the top of which is a level sandy plain stretching out on both sides of the river. On the brow of the bank, a few boulders of gneiss are lying, while below it is a scarped bank forty feet high, apparently composed throughout of reddish sand with a few pebbles. Below

* The Red River, by J. McDonell. L. R. Masson, Vol. I., pp. 275-285. Montreal, 1888.

this, the hillside is very rough and uneven, the banks, having fallen in a succession of slides, leaving small trough-like valleys above and behind each other. The surface of the slides are sand, but they are doubtless sliding on the soft Pierre shales.

Three miles further south on the east side of the river, a clear brook of cool water six feet wide and six inches deep flows from a wide open valley. The original bottom of this valley is about 120 feet above the bottom of the valley of the Assiniboine. Close to its mouth the brook has cut a V-shaped gorge down through this old bottom land, leaving rugged hills, on the top of which the old terrace can occasionally be detected. On the opposite side of the Assiniboine valley is a sloping terrace at about the same height.

V-shaped gorge.

Two miles further down the Assiniboine, a wide valley drained by Two Creeks, joins the main valley from the north-west. The valley of the Assiniboine immediately changes its direction towards the south-east, assuming the direction of the valley of Two Creeks. At the same time it has more extensive bottom lands, and the stream which has been sluggish for a long distance, becomes somewhat more rapid. Elm trees are seen in the valley here for the first time.

The valley maintains the same character for ten miles, to the mouth Many springs. of Big Boggy Creek. Many small rills flow down the slopes into the river, and bare slidden banks near the brim of the valley attest to the presence here of the bed of sand previously seen, from under which the rills probably have their sources. The Pierre shales were seen in very few places.

Big Boggy Creek.

Big Boggy Creek at its mouth is thirteen feet wide and two feet deep with a current of a mile an hour. It flows from a wide valley, the bottom of which seems to be about fifty feet above the level of this river, but like the stream described above, it has cut a narrow V-shaped gorge in the old floor of this valley in descending to its mouth.

Below the mouth of Big Boggy Creek the river turns again to the south. It is 100 to 120 feet wide and flows with an easy current. The east side of the valley is generally wooded, while the west side is often bare, or dotted with groves of small poplars. The banks of the channel consist of alluvial sand, but at a few of the outer bends large boulders give evidence of the presence of till, and nodules of ironstone show that the Pierre shales are not far away.

Upper and lower till.

Just south of the middle of Township 25, Range 29, where the valley is 240 feet deep, the higher parts of the east bank show some interesting exposures of till and stratified sands, &c. At one point, below three feet of stratified sand at the surface, are fourteen feet of brownish-gray

unstratified till, holding a number of boulders of gneiss and limestone, many of which are striated by glacier action. In another section twenty-five feet of till were shown. The upper six feet are here separated by a distinguishable colour-line from the lower. Along this line most of the boulders are lying, and in one place the two tills are separated by a thin lenticular bed of sand and gravel. It is also interesting to note that the boulders are all smoothed and striated on the upper surface, while many of them are otherwise rough. The boulders are imbedded for the greater part of their depth in the lower harder till, and when they are undisturbed the striae appear to trend in a constant direction, viz., S. 75° — 80° E.

Pavement of
striated
boulders.

A similar observation was made on boulders imbedded in the surface of the till near the bank of Silver Creek, a mile east of Binscarth. The place was a borrow-pit north of the railway track, in which many boulders were lying about. All of these were seen to be well polished and striated on one side. Twelve boulders were found in place in the till, and in all the upper surfaces were smoothed, striated and horizontal. The striae were parallel throughout, trending S. 45° — 55° E. They had the same character, and had clearly been formed in the same way, as the striae on the limestone surfaces around the great lakes to the north-east. The whole surface of the older till had been passed over by the glacier of the Assiniboine valley moving south-eastward, and the hard boulders had retained the striae.

Boulders at
Silver Creek.

From the above point to the mouth of Shell River the river is from Sloping valley 150 to 200 feet wide, with a very easy current. The banks of its channel are six to ten feet high and composed of stratified alluvial deposits. Wide grassy bottom lands with occasional groves of elm extend across the valley, whose sides are generally also grassy or dotted with groves of poplar in the little ravines. Some nodules of ironstone with a few crystals of selenite are lying on the slopes, having been weathered out of the underlying Pierre shales.

Shell River flows with a swift current out of a wide V-shaped valley, and across a level flat through a beautiful grove of large elms.

From the mouth of Shell River to the village of Shellmouth the Rapids. river is rapid; sand and gravel bars stretch out from the points into the stream. In places a wide meadow land fills the bottom of the valley, and in other places a terrace thirty feet above the river skirts its banks to the north. This is the first terrace seen in the valley since leaving the mouth of Little Boggy Creek.

In this piece of river an old location of the Canadian Pacific Rail- Old C.P.R. way crosses the valley, the bottom of which is stated upon the profile to be 1,335 feet above the sea.

Shellmouth.

The small village of Shellmouth is situated on the east side of the river, where five beautiful open terraces form a series of steps up the side of the valley.

The country on the top of the bank, about 230 feet above the river, is level and underlaid by sand and gravel with a few boulders, which latter are found in greatest number along the brow of the hill. Here a few stunted oaks are growing. Descending a scrubby slope for 100 feet, a sandy terrace is reached, 625 paces wide on the trail, on which there are no pebbles or large boulders except along its brow, where the land is three or four feet higher than that behind, forming a ridge on which a large number of boulders are scattered. This ridge is precisely similar to the present bank of the river in many places, where the lands back from the stream descend several feet to a hay meadow.

From the brow of this terrace a long slope descends to a sandy flat, the whole distance on the road being 500 paces. The brow of this flat, which is thirty-five feet below the last, or ninety-five feet above the river, is strewn with many small rounded and water-worn boulders up to one foot in greatest diameter. Four hundred paces further west along the road brings one to the edge of a similar terrace eighty feet above the river. The land is mostly sand, but a pit three feet deep on the edge of a terrace shows it to be composed of rounded water-worn gravel, with rounded boulders of gneiss up to eighteen inches in greatest diameter. The gravel shows little or no sign of stratification.

Two hundred and thirty paces, for the most part down a gentle slope, brings one to the edge of a terrace fifty-five feet above the river, and again 225 paces lead to the edge of a low terrace close to the river, fifteen feet above the bottom land, and twenty-five feet above the water.

West bank
steep.

The west bank of the valley rises steeply from the alluvial bottom land without any sign of terraces, and at no other place in the whole Assiniboine valley are terraces so beautifully shown as they are at Shellmouth.

For the rest of the distance to Millwood, which is situated five miles south of the limit of the present map, the river is very similar in character throughout.

Lightly un-
dulating
country.

Ascending the east side of the valley a mile north of the mouth of Skunk Creek, the country is generally level, though in detail lightly undulating. The surface is sandy and through the sand are scattered a few pebbles, but no boulders. Standing on the brow of the hill lovely prospects of the valley extend to the right and left. The sides are steep and more or less irregular, having been fashioned by ancient land-slides that are now overgrown with grass or coppice, form-

ing a declining series of little rounded or elongated knolls, some of which carry a few small oak trees. No terraces are present here, but one can be seen above the mouth of Thunder Creek. Between the hill-sides, lies a beautiful green alluvial floor half a mile wide through which the river winds, its banks thinly fringed with poplar, elm or willow.

At the top of the bank is a land-slide showing in descending Till order one foot of sandy loam underlaid by a thin irregular stratum of pebbles and small boulders. Then six feet of a light yellowish-gray unstratified till containing pebbles up to the size of the fist, many of which show clear glacial striae. Below this is a lenticular mass, fifty feet or more in length, tapering off to both ends, and eight feet thick in the middle, of very irregularly stratified sand and gravel, into which are projecting at the ends bands of unstratified till. The upper part, having a thickness of four feet in the middle, is a soft sand or fine gravel, while the lower four feet is much more compact, and is more closely allied to the till. The whole deposit has possibly been formed by a stream flowing under the ice of the glacier. It is underlaid by at least three feet of light gray till. Lower down the bank Pierre shales were seen.

A short distance to the south, Smith and Skunk creeks flow into the Assiniboine nearly opposite to each other, the former having deposited a little bar of gravel at its mouth. Skunk Creek has formerly cut out a wide valley, and at and below its mouth the alluvial banks of the river are composed to a considerable extent of stratified gravel, the pebbles of which consist of light gray Odanah (Upper Pierre) shale, Odanah shale. which has been washed out of this valley. These gravels are the first indication seen on the river of the presence of Odanah shale on the adjoining higher land. The shale is mixed with many very perfect shells of *Unios*, pieces of buffalo bones, &c.

A short distance below Skunk Creek several exposures of Pierre Millwood (Millwood) shales were seen in the banks, but it is not until the village shale. of Millwood is reached, five miles south of the limit of the map which Millwood accompanies this report, that a good section can be obtained. Here the Manitoba and North-western Railway crosses the valley, and its many deep cuttings show in all more than 200 feet of a very homogeneous dark-greenish gray clay shale with nodules of calcareous ironstone. Some of these nodules show cone in cone structure, and others contain such typical Pierre fossils as *Scaphites nodosus*, var. *quadrangularis*, *Lucina occidentalis*, *Baculites compressus*, *Pteria linguiformis*, *Inoceramus tenuilineatus*, *I. Sagensis*, var. *Nebrascensis* *Nucula* sp., *Dentalium gracile* ?, elytron of *Hylobiites cretaceus* and fragments of fishes.

The lower part of the bank is covered, but probably consists of similar shale, and a well dug by the railway on the flat to a depth of 100 feet, is said to have passed to the bottom through similar shale to that in the bank. This would give a thickness of 350 feet of Lower Pierre (Millwood) shales.

The bed of the river at Millwood is 1,309 feet above the sea.

Wells.

West of the valley, along the railway track, the wells dug by the railway company give some interesting sections.

Harrowby.

At Harrowby, just on the top of the west bank, the surface is 1,593 feet above the sea, and a well has been dug on a high alluvial plain or terrace that extends from half a mile to a mile back on both sides of the river. It is 100 feet deep; the upper eight feet passes through stratified sand, and the remaining ninety-two feet through dark gray Millwood shales holding large round and dumb-bell shaped concretions of ironstone. Seven miles further west, near the crossing of the old Ellice and Pelly trail, the surface is 1,640 feet above sea level, and a well was dug 163 feet entirely through gray till, to a bed of gravel from which a plentiful supply of water was obtained. The till holds many pebbles and small boulders of gneiss and limestone, most of which are more or less polished and striated.

Langenburg.

At Langenburg, where the surface is 1,681 feet above the sea level, a well was dug to a depth of 175 feet, the log stating that 165 feet was through clay and ten feet through sand. The material around the mouth of the well was examined, and found to be a bluish clay, apparently mostly derived from the Millwood shales. It is mixed with small pebbles, and a few boulders of gneiss and limestone, the latter of which are beautifully polished and striated.

Churchbridge.

At Churchbridge, where the elevation is 1,740 feet, a well six feet in diameter was dug to a depth of 267 feet. The following is the log as received from G. H. Webster, C.E., engineer of the railway:

Description of material passed through.	Thickness of bed.	Depth of bottom of bed from surface.	Height above sea.
1. Sandy loam.....	8	8	1,732
2. Clay, with gravel and small stones.....	12	20	1,720
3. Gray sand	2	22	1,718
4. Rocks and clay, about all rocks.....	3	25	1,715
5. Blue clay and small stones.....	7	32	1,708
6. Gray sand.....	1	33	1,707
7. Soft blue clay with layers of sand 1 inch thick about every 2 feet. No pebbles or boulders.....	234	267	1,473

In bed No. 5 water was obtained at thirty feet, rising one foot in twelve hours.

In No. 7 small springs of water were struck at eighty and 250 feet. At a depth of 200 feet a well preserved piece of wood six inches in length was found, and has been described by Prof. D. B. Penhallow as a new species of larch under the name *Larix Churchbridgensis*.* The same species was also found in southern Manitoba in post-glacial deposits.

This well has not been visited by the writer, but the beds from 2 to 5 would appear to be quite certainly glacial till, while No. 7 would appear to be a great thickness of inter-glacial (or possibly pre-glacial) clays which have been deposited in a valley or lake basin, before the final advance of the ice which distributed the uppermost till, and striated the surfaces of the boulders imbedded in the lower till.

A deposit of similar age is shown in the railway cuttings on the Bird Tail east side of the valley of Bird Tail Creek, where twenty-five feet of Creek. stratified sand and gravel is overlaid by twenty-five feet of unstratified till with striated pebbles and boulders.

At Russell, a terminus of the Manitoba and North-western Railway, Russell. six miles east of the Assiniboine, and 1,830 feet above the sea, the country is all thickly covered with drift. A well half a mile south of the station was dug through 100 feet of light gray till, in which were some polished and striated boulders of gneiss 2 x 4 feet in diameter. 400 yards further east in a light rise, the till was but a few feet in depth, below which the light gray Odanah shales were met with.

At Dr. Barnardo's farm, three miles W.S.W. of Russell, and at about Barnardo farm. the same elevation, a well has been dug 170 feet through the light gray Odanah shales to the top of the soft dark Millwood shales. This would place the base of the Odanah series here at an elevation of about 1,660 feet above the sea. The surface is irregularly undulating, and here and there are ridges of gravel, often interstratified with till, which have probably been formed beneath the ice of the great glacier of the Assiniboine valley.

*A new species of *Larix* from the Interglacial of Manitoba. By D. P. Penhallow Am. Geol., Vol. IX. p. 368, June, 1892.

DESCRIPTIVE GEOLOGY.

Formations. The geological terranes referred to in this and the preceding chapter are shown in descending order in the following scheme :—

- Recent.
- Post-Tertiary—
 - Champlain.
 - Glacial.
- Crétaceous—
 - Pierre.
 - Odanah.
 - Millwood.
 - Niobrara.
 - Benton.
 - Dakota.
- Devonian—
 - Upper Devonian or Manitoban.
 - Middle Dévonian or Winnipegosan.
 - Lower Devonian, covered or absent.
- Silurian—
 - Niagara.

Fuller descriptions of these terranes are given in the succeeding chapter on Systematic Geology.

SASKATCHEWAN RIVER.

Mouth of river.

Ascending the Saskatchewan River from the point where it empties into the west side of Lake Winnipeg, the banks for a short distance are low, but they almost immediately rise to a height of fifteen feet and maintain this height up to the foot of the rapids at a distance of two miles and a half from the lake. They are generally sloping and covered with grass, but they appear to be composed entirely of a light yellowish-gray till, while the little beach at the foot of the abruptly sloping bank is strewn with many irregular fragments of white limestone.

Abandoned channel.

Just above the Hudson's Bay Company's post, on the west bank of the river, an old abandoned channel joins the main course of the stream. It varies considerably in width, from a quarter of a mile at its mouth to about 200 yards a mile further to the south, where it again joins the main channel of the river. At this latter point its bed was five feet above the level of the surface of the river in August, 1890. A short

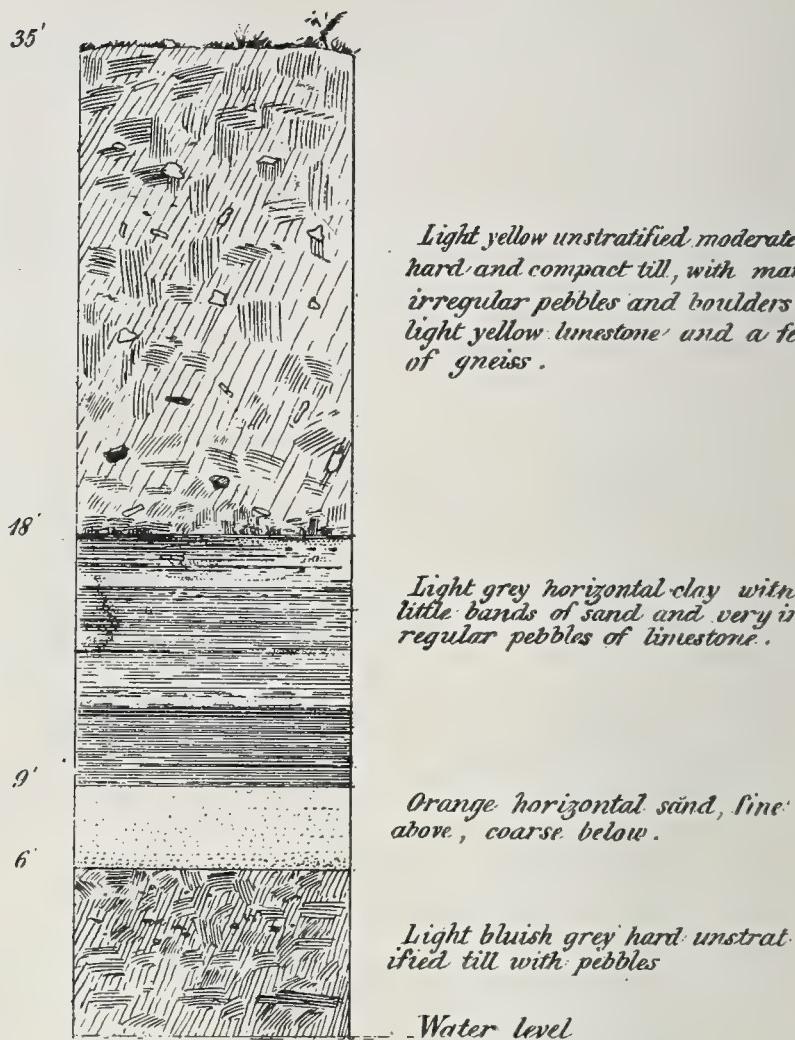
distance from the upper end of the channel a small stream begins to flow down the channel, and after babbling through and among the irregular angular stones with which its floor is covered, falls into the bay at its mouth. In seasons of flood some of the water of the river is said still to flow down this channel. Its banks are from forty to fifty feet high, but are throughout covered with trees or deciduous plants.

On the east side of the old island, which is cut off by this abandoned channel from the high land to the west of it, the river is in some places still cutting down its bank. At one place, a few hundred yards below the head of the old channel, a low exposure of Niagara limestone is seen close to the edge of the river, rising at its highest point to two feet above the water. Its bedding is essentially horizontal, and its surface is smooth and glaciated with strongly marked parallel grooves bearing S. 2° W.

The rock consists of a brecciated magnesian limestone, the pebbles in which are milk-white, very compact, though rather soft, and highly argillaceous, breaking with a vitreous fracture. The matrix, which is much harder but less compact, and often slightly porous, is yellowish-gray, and breaks with a stony fracture. The rock is rather thinly, but irregularly bedded, and along the edge of the water weathers to a light yellow, while the upper part away from the water weathers to bluish-gray. No fossils were found in this band.

A little further south on the same side of the island a scarped and springy bank thirty-five feet high shows the section of the Pleistocene deposits represented on the following page. The face of the upper portion of the cliff weathers to a milk white. The line between the upper till and the stratified clay is not very sharp, the one appearing to merge almost imperceptibly into the other, while the pebbles become larger and fewer in descending to where the clay is more distinctly stratified. The sand below the clay is very fine at the top, and passes downwards into a fine gravel. The lowest bed of till is partially covered with debris, but both the top and bottom were clearly seen.

**Section of Pleistocene
at Grand Rapids.**



A considerable flow of water rises from the band of sandstone, and the bank below it is generally covered with debris consisting largely of angular fragments of limestone, much of which is derived from close at hand.

The rest of the west bank of this old island, with the exception of the low outcrop of Niagara limestone mentioned above, is covered with debris from these surface deposits, and boulders and pebbles are scattered along the edge of the water. One very large boulder of limestone, fifteen feet in length, is lying in place on the glaciated surface of the limestone, still partly imbedded in the bottom of the

till. It is strongly glaciated, its sides being everywhere scored with striae.

Following the north bank of the river above the upper end of the *Pentamerus* old channel to the first prominent point, a thick-bedded buff-coloured dolomite crops out at the edge of the water, holding a large number of *Pentamerus decussatus*, and then crossing to the south side of the river, in a direction 25° south of east the *Pentamerus* band is again seen with a thickness of two feet. It is exposed at the top of a little cliff, and is underlaid by nine feet of whitish moderately thin-bedded unfossiliferous dolomite. One foot at the bottom is more yellowish and a little thicker bedded than the rest. The brecciated zone is not seen, but is doubtless but little below the beds seen in this cliff.

In the *Pentamerus* band at the top of the exposure *Pentamerus decussatus* is very abundant, and the following other fossils are found associated with it, viz.: *Favosites Niagarensis*, *Alveolites Niagarensis*, *Lyellia papillata*? *Halysites catenulatus*, *Orthis* sp., *Euomphalus* sp.

Following up the south bank of the river for a quarter of a mile, the *Pentamerus* band, which has a total thickness of from three to four feet, disappears beneath the level of the water, and the cliff dies away and leaves a willow flat that may be the lower end of an old channel on the south side of the river. In one place, however, east of this flat the *Pentamerus* band is overlaid by three feet of white moderately thin-bedded limestone. Continuing to ascend the course of the stream, soft yellow or white argillaceous limestones are occasionally exposed on both banks up to within a short distance of the foot of the old portage. It is difficult to give an exact section of these beds, as where they are unprotected by overlying harder rocks they have been more or less completely removed during Pleistocene times, and where so protected the foot of the cliff is buried in a talus of angular fragments from the dolomite above. They would appear to be from forty to fifty feet thick, and the following is the ascending section as seen, the width of the first gap being uncertain.

Section below
old portage.

Three feet of white moderately thin-bedded limestone (mentioned above).

Ten? feet covered.

Eight feet of a soft light yellow argillaceous limestone, generally porous and containing a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernable and the rock breaks into very irregular lumpy pieces. Lying on the shore, and apparently derived from this band, are some nodules of marcasite, and red masses of iron-stone.

Fossils are not plentiful on the south side of the river where this band is best exposed, but a low exposure on the north bank that seems to be a continuation of that on the south bank contains *Strophomena acanthoptera*, *Leptocelia* and *Lepiditria*.

Six feet covered.

Section below
old portage.

Fifteen feet of a thin-bedded white horizontal chalky limestone, in places argillaceous, very light and breaking regularly when struck with the hammer. It has a more or less granular structure, occasionally approaching a sandstone in appearance. One bed near the top was strongly ripple marked, and on the edges of slabs broken from this bed the action of the water that covered these ripple marks is seen to have extended down from an eighth to a quarter of an inch, and to be defined by a moderately even horizontal line. A thin band a few feet below the top was found to contain a considerable number of fossils; among which the following have been recognized:—*Favosites Niagarensis*, *Leptocelia* sp., *Rhynchonella*, sp., *Pterinea aviculoides* ?, *Pleurotomaria occidens* ?, *Pleurotomaria* sp., *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia cœca*, and *L. Hisingeri*, vars. *egeana* and *fabulina*.

Dolomites.

The white Lower Niagara limestone is sharply overlaid by a hard, tough, light yellowish dolomitic limestone, rather indistinctly bedded. It is generally clearly fragmental, and towards the base contains a large number of impressions of salt crystals. Fossils appear to be moderately plentiful, but they are very difficult to break out and consequently few were collected. Crinoid stems are very abundant, and with them were *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoidal limestone has a total thickness of ten feet and grades up into, and is overlaid by from twenty to thirty feet of a hard brittle yellow dolomite, everywhere evenly bedded and often breaking into thin slabs. The only distinct fossil is a large Stromatoporoid, which occurs most abundantly in the upper strata and often gives the surface the appearance of many closely adjoining low domes. The rock is much jointed and breaks with a smooth porcellanous fracture.

Gorge at
Grand Rapids

These dolomitic limestones form the sides of the gorge through which the Saskatchewan flows at the Grand Rapids, standing in abrupt cliffs that often overhang the torrent below. On the south side the foot of the cliff is in places piled with a talus of angular fragments, while on the north side it descends abruptly into the water.

Tramway.

At the upper end of the rapids these compact dolomitic limestone are overlaid by a porous yellow dolomite, generally in moderately thin but uneven beds, and containing many impressions of salt crystals. No fossils were obtained here, but on the tramway similar rock is exposed at a number of places near the top of the grade, and at heights rising to forty feet above the level of the top of the compact dolomite at the head of the rapids. It here contains *Lyellia papillata* ? and several other species of corals, with some large Stromatoporoids. It is here best exposed in a cut through two gravel ridges on the brow of a long slope facing towards the east.

About half-way across the tramway a slight surface outcrop exposes two feet of horizontal, gray, white-weathering, thick-bedded, tough but

rather porous dolomitic limestone, and immediately adjoining is a coarse breccia, in which the pebbles are derived from the adjoining rock, while the matrix is dolomite containing a large quantity of coarse well-rounded quartz sand. It would appear probable from its very local occurrence that this is a fault breccia, in which case the origin of the sand is an interesting question, as the only sands of the same character known in the region are the St. Peter's Sandstone below the Trenton, and the Dakota Sandstone at the base of the Cretaceous, though the nearest point at which the latter terrane has been actually observed, lies seventy-five miles to the south-west.

As will be seen by referring to page 182, a somewhat similar breccia occurs at Point Wilkins, on the west side of Dawson Bay, the sand in which has undoubtedly been derived from the base of the Cretaceous. As the sand is much more likely to have run down from above, rather than to have been squeezed up from below, its presence here may denote the former existence of the Dakota Sandstone previous to the wearing back by erosion of the great Manitoba escarpment.

Ascending the river from the upper end of the tramway, the banks are at first low, or rise in cliffs of glacial and alluvial deposits, but at a distance of two miles and three-quarters, Niagara limestone again makes its appearance on both banks of the stream. On the north side it is a thin-bedded, yellowish-gray, compact, dolomitic limestone very like the beds at the Grand Rapids, and like in them, the surface rises in little low domes, probably from the presence of large Stromatoporoids. On the south bank is a cliff eight feet in height of an orange-gray dolomitic limestone, both thin and thick-bedded. It is very hard and compact, many of the loose slabs ringing sharply when struck with the hammer.

Half a mile further up the river a little cliff six feet in height projects into the stream, and the water rushes past its base with considerable velocity. Its top is a small open meadow covered with grass and strawberry vines. It is composed of horizontal, hard, compact, resonant dolomitic limestone, mostly in beds from half to three-quarters of an inch in thickness. Towards the bottom the rock is rather thick-bedded, not so compact and contains Stromatoporoids, Leperditiae and other fossils. The weathered surface is generally white, but a new fracture is buff, and where it has been heated by forest fires it is a bright red. The fracture is generally stony, but in some of the larger pieces cut by veins of calcite it is conchoidal.

For the next half mile the shore is composed of similar rock, in places rising into little cliffs, and in other places forming a wide flat, strewn with angular fragments torn off by the ice.

Roche-rouge

One bed was found to contain a great number of cavities out of which salt crystals had been dissolved. The salt has originally composed about a sixth of the mass of this bed.

Fossils.

Another stratum, which is often quite red, contains a great number of specimens of *Isochilina grandis*, var. *latimarginata*, with an occasional example of *Leperditia phaseolus*, along with crinoid stems, *Leptocelia* sp., and the tail of a *Dalmanites*? In contiguous beds were found *Stromatopora*? sp., *Zaphrentis* sp., *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Lyellia papillata*? and *Strophomena acanthoptera*.

A short distance further up the stream a low cliff, half hidden by the woods along the shore, shows at the bottom compact thin-bedded dolomite similar to the last, overlaid by seven feet of thick-bedded yellow porous dolomite, weathering with a rough pitted face. The rock is brought up by a very light anticline in the centre of which six feet of the thin-bedded dolomites are exposed.

The bank of the river north of Roche Rouge Rapids is an abrupt cliff ten to fifteen feet high, and appears to be composed chiefly of white till with boulders, with a narrow ledge of limestone close to the edge of the water.

Cross Lake
Rapid.

At the foot of Cross Lake Rapids a rather conspicuous point projects from the south bank and forms a cliff 150 yards long and ten to fourteen feet high. The limestone composing it is practically horizontal. Four feet at the bottom is a compact hard yellowish-gray dolomitic limestone in thin regular beds, and this is overlaid by ten feet of a thicker and less evenly bedded dolomitic limestone. The upper four feet of this latter bed weathers with a moderately even face. The lower six feet, lying above the slaty dolomite, is very uneven in texture, having compact streaks through it, while much of it is soft and rotten, and generally of a lighter colour than the rest; it weathers with a very rough face and often has the appearance of a conglomerate on account of the presence of many nodules that when broken show the structure of Favosites or Stromatopora.

Fossils.

This nodular band contains a considerable number of fossils, of which the following have been recognized: *Stromatopora*? sp., *Calapœcia* sp., *Zaphrentis Racinensis*?, *Cyathoxonia Wisconsensis*?, *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Lyellia papillata*? crinoid stems, a polyzoon, *Trematospira formosa*?, *Murchisonia* sp., *Pleurotomaria Hoyi*?, *Orthoceras* sp., *Isochilina*, sp.

At the upper end of Cross Lake Rapids, where the river flows out of Cross Lake, a very similar cliff forms a prominent feature on the

south shore. It consists of horizontal buff-coloured, dolomitic limestone, the top beds of which are thick, compact, and very hard, while four feet at the bottom are very soft, like the upper beds at the foot of the rapids. The harder beds contain a few imperfectly preserved fossils, and also some large and regularly preserved casts of single crystals of salt.

On the south shore of Cross Lake there are many little cliffs of Cross Lake, apparently similar limestone. One of these, near the west side, was found to consist of four feet of thick-bedded yellowish, rotten, dolomitic limestone similar to that at the last rapids, and containing a few fossils such as *Stromatopora?* sp., *Favosites Niagarensis*, crinoid stems, *Strophomena acanthoptera*, &c. It is underlaid by compact thinner-bedded dolomitic limestone apparently holding no fossils.

At Demi-charge Rapid similar hard dolomite forms low cliffs on both banks, and just above the rapid a cliff on the south shore rises to a height of from fifteen to twenty feet, composed throughout of light yellowish-gray horizontal dolomitic limestone, both thick and thin-bedded, and generally hard and compact. The only fossil seen was the common *Strophomena*. A little higher up the river a cliff eight feet high faces the stream, above which is a terrace, apparently an old shore line, extending back to the foot of a cliff twelve feet high, and now overgrown with trees. The foot of the lower cliff is strewn with sharp angular fragments broken from its face. The bottom bed is filled with shot-like concretions, which weather into little pits.

On the west side of a small lake-like expansion about a mile and a half further up the stream, a very similar hill is seen with a cliff ten feet high facing the water, and another cliff rising ten feet higher behind a terrace in the poplar woods. The rock at the bottom is a thin-bedded dolomitic limestone, above which is a thick-bedded, rotten, dolomitic limestone, and this again is overlaid by a harder compact evenly bedded dolomitic limestone. Some of the middle beds contain a few fossils such as *Strophomena acanthoptera*, *Rhynchonella*, *Leptocelia*, &c.

Also at the north-east point of land below "the Narrows" low cliffs The Narrows, of similar thin-bedded dolomitic limestone occupy the shore for several hundred feet.

South-westward from "the Narrows," which is accounted as the Cedar Lake, eastern extremity of Cedar Lake, a gradually widening arm extends for twelve miles to the main body of the lake. It is dotted with many beautiful rocky islands, and while the north shore is generally low and wooded, the south shore rises in many places in prominent cliffs from fifteen to twenty-five feet in height.

Rocky islands. The rock on both the islands and the shore is very much the same throughout, consisting of light yellow, very hard and compact dolomitic limestone varying greatly in the thickness of the beds. The base of the cliff is generally covered with a pile of large angular blocks fallen from the thicker beds towards the top. The summits of the cliffs are generally level, but do not show glacial striæ, as they have evidently been eroded by meteoric agencies, while some of the rocky islands that rise but a very few feet above the water, and from whose surface the till has probably been very lately removed, show beautiful glacial striæ bearing S. 18° W. Very few fossils were found in these rocks, the only one that was recognized being the common *Strophomena acanthoptera*.

From Rabbit Point westward, the south shore alone was examined, Fort Island. and no Palæozoic rocks were seen between that point and Fort Island.

At the north point of this island a little vertical cliff six feet high, composed of horizontal light orange-yellow porous dolomite in heavy even beds, rises from the edge of the water. It contains a considerable number of fossils, of which the following were collected: *Cyathaxonia Wisconsinensis?* *Zaphrentis Racinensis?* *Omphyma?* sp., *Alveolites Niagarensis*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Leptocælia?* sp., *Meristella?* sp., *Trematospira?* sp., *Orthoceras* sp., and *Leperditia Whiteavesii*.

West shore of Cedar Lake.

From Fort Island westward many of the islands around the mouth of the Saskatchewan, as well as points on the shore, both to the north and south, are composed of similar dolomite. On a prominent point projecting from the south shore, the rock is a light coloured dolomite, yellow in places where it is much acted on by the water. In some places it is thin-bedded and almost slate-like, but generally the structure is concretionary on a large scale, so that the surface has a mammillated appearance, the domes being from six to twelve feet in diameter, and in them the thin-bedding is lost and the rock becomes somewhat porous. They inclose such fossils as *Favosites Niagarensis?*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Rhynchonella altiplicata?*, *Atrypa reticularis*, *Polytropis*, sp.

The shore is here piled with great angular blocks from three to four feet in thickness that have evidently been broken from a bed just below the level of the water and piled up into their present position by the ice.

Chemahawin.

Chemahawin, where the Hudson's Bay Co. have a trading post, was the most westerly point on the Saskatchewan River reached by the expedition. In its immediate vicinity from eight to ten feet of horizontally bedded dolomite outcrops on the bank. It is generally

light gray, and sometimes compact, but it is often yellow and porous, and is throughout very thick-bedded. A careful search revealed the presence of such fossils as *Favosites Gothlandica*, *Favosites Niagarensis*, *Alveolites Niagarensis*, *Halysites catenulatus*, *Strophomena acanthoptera*, *Leptocælia*, sp., *Orthoceras* sp., *Illænus* sp., and *Leperditia Whiteavesii*.

Leaving Cedar Lake at its south-western angle, a winter trail, known as the Western Mossy Portage, leads through a thinly wooded tamarack swamp on a gently rising plain to the shore of Lake Winnipegosis.

LAKE WINNIPEGOSIS.

Following the shore eastward, no Palæozoic rocks are seen up to the north-east angle of the lake, but on the north-west point of Ami Island flat-lying and thin-bedded yellowish magnesian limestone of Niagara age is seen for the first time. Following the shore of the island this limestone, which is at first slightly porous, becomes hard, thin-bedded and flint-like, and the bedding becomes wavy. In places North-east shore. it contains large nodules of gray chert. Probably from ten to fifteen feet of rock in all is exposed on this island. It contains a considerable number of species of fossils among which *Strophomena acanthoptera* is the most abundant, while *Pterinea* sp., *Grammysia* ? sp., *Murchisonia* sp., and *Pleurotomaria* ? sp., also occur.

East of Ami Island the beach is flat and sandy, but generally scattered over with fragments of dolomite. Some of these are Silurian peninsula. and doubtless of more or less local origin, while others are Devonian, and contain such typical fossils as *Stringocephalus Burtini*.

These are evidently transported masses, and as the direction of Boulders. glacial transportation is from N. 20° E., as shown by glacial grooves and striæ in the immediate vicinity, they would prove the existence of the *Stringocephalus* dolomite in the unknown area between this point and the south end of Cross Lake during the latest glacial times, and it is not improbable that an outlier of this dolomite still exists, and forms a capping to the high land seen in that direction. On Ami Island boulders of the *Pentamerus* band in the Niagara series are also found, having been brought from the same direction, and with them are small rounded masses of white sandstone holding nodules of Marcasite. These are similar to the nodules found on Pemican Island described on page 169, and like them are not improbably derived from an outlier of Dakota sandstone in the immediate vicinity. In view of the fact that Marcasite readily undergoes decomposition into soluble sulphate of iron, which would soon be washed away by the waves

Nodules of
Marcasite.

it would appear that these nodules have only recently been shoved up on the beach, and could not have been transported from the north so long ago as the glacial age. We must, therefore, infer that a small outlier of Dakota sandstone exists beneath the level of the water on the south side of this island, and that it has been protected from destruction, at the time when the Laurentide glacier passed southward over the country, by the shelter of the island to the north of it, and that it is even now touched and scraped by the lake ice only in seasons of extreme low water, such as was the summer of 1889.

Low sloping rock.

Returning to the shore at a point opposite two small islands, originally bedded rock outcrops at the edge of the water, consisting of a fine-grained yellow, moderately compact magnesian limestone, fairly thickly and evenly bedded, and breaking under the hammer in any desired direction.

Following the shore southward the beach is strewn with angular fragments of magnesian limestone, similar to that already seen, broken by the ice and frost from the beds below. Some chalybeate springs flow out on the beach, and in the vicinity is a light yellowish or pinkish dolomite holding typical Niagara fossils, as well as chert concretions.

Fossils.

At lat. $52^{\circ} 54' 15''$ in a little bay just north of a point of land, the beach consists of a light gray thin-bedded compact dolomite in which the impressions of ostracods are very numerous. The beds have a slight dip S. 80° W. and are very much cut by parallel jointage planes running from south-west to west. The following fossils were found in this dolomite: *Streptelasma* sp., *Strophomena acanthoptera*, *Rhynchonella* sp., *Ilionia?* sp., two species of *Murchisonia*, *Pleurotomaria* sp., *Orthoceras* sp., *Isochilina grandis*, var. *latimarginata*, *Leperditia Hisingeri*, and its vars. *fabulina* and *gibbera*, *L. marginata*, and *Acidaspis perarmata*.

Massive dolomite.

At the point itself a massive porous dolomite from eight to ten inches in thickness makes its appearance, being apparently about three feet above the strata just mentioned. It is apparently made up largely of remains of Stromatoporoids and contains many large concretionary nodules of chert. Continuing further south this layer is overlaid by a few feet of similar but thinner bedded dolomite, the bedding planes of which are generally rough and irregular. The most common fossil here is *Strophomena acanthoptera*.

Thin-bedded dolomite.

In lat. $52^{\circ} 52' 30''$ the shore is composed of thinly stratified dolomite holding *Strophomena acanthoptera*. The beds are generally undulating and some are slightly porous, while others are very compact and porcellanous. They all appear to dip lightly out into the lake in a direction S. 85° W., and the bottom for a long distance is a gently inclining surface of smooth rock.

Similar rock forms or underlies the beach all the way to the point of the peninsula, generally thin and evenly bedded and broken into sharp angular fragments by jointage planes, which are often arranged in concentric circles.

For a mile and a quarter up from the point, on the east side of the peninsula, the shore is low and the water off it is very shallow, and then for three-quarters of a mile the Niagara rocks again make their appearance. At first is a low exposure on the beach showing two feet of light yellow porous dolomite in rather thick beds, in which neither fossils nor chert nodules were seen. 100 yards to the south of this exposure is a spring surrounded by a red slime. The water tastes distinctly of common salt and sulphuretted hydrogen.

At a point north of this portion of the shore the rock is thick-bedded, holding a large number of nodules of chert, being apparently a continuation of the cherty dolomite seen in lat. $52^{\circ} 54' 15''$ on the opposite side of the peninsula. This would indicate a strike of N. 20° W. for these rocks, which agrees fairly well with that which would be deduced from the dips given above.

The shores of the deep bay to the east of this peninsula are generally low and without rock exposures, while across its north end extends the high ridge that has continued quite unbroken from the northern point of the lake west of Western Mossy Portage.

At a prominent point on the east side of the bay, in lat. $52^{\circ} 53' 10''$, Silurian dolomite again makes its appearance on the shore. It is yellowish-gray, more or less compact and thick-bedded, and rises in a light anticline striking S. 50° W., though the general dip of the beds also appears to be in that direction at a low angle. Here and there throughout the rock are small cavities, the sides of which are lined with loose semi-crystalline dolomite. Small nodules of chert are not uncommon, but other fossils than *Strophomena acanthoptera* are very rare.

Two miles to the southward a rather thin and not very evenly bedded dolomite underlies the beach. It is in places of a light colour, more or less coarse-grained, and contains nodules of chert, with *Strophomena acanthoptera* and other fossils, while in other places it is very compact and much fractured, and contains *Isochilina grandis*, var. *latimarginata* and other ostracods, with a species of *Proetus*.

The beds are evidently the same as those outcropping in lat. $52^{\circ} 54' 15''$ on the west side of Long Point peninsula, and a line connecting the two points would indicate a strike of N. 40° W. This varies considerably from the strike previously obtained and serves as an instance of the fact that neither strikes nor dips are at all constant in detail in these flat-lying beds.

Beach of angular pebbles.

A mile further to the south, and near lat. $52^{\circ} 50'$, the shore is composed of thin-bedded hard dolomite cut by many jointage planes, and the beach is scattered with angular fragments of the same rock, but near the south end of this exposure the dolomite becomes very porous and uneven and contains a considerable number of fossils, most of which were too fragile to permit of being broken out, but concretions of chert are almost entirely absent. Among the fossils *Strophomena acanthoptera* was the most common, while species of *Murchisonia*, *Orthoceras*, &c., were also collected.

A short distance further to the south thin-bedded dolomite is again seen, and the rest of the shore as far as the point consists of angular fragments of dolomite scattered through a matrix of soft clayey sand flattened and grooved by the shoving of the ice in spring.

South of the point the shore turns eastward for two miles and a half at right angles to the direction of glaciation, and then turns again and continues parallel to its former direction.

Vesicular dolomite.

In lat. $52^{\circ} 46'$ light gray porous or almost vesicular dolomitic limestone makes its appearance in beds of from half an inch to an inch in thickness. It continues for a mile along the shore and becomes quite fossiliferous, containing large numbers of *Strophomena acanthoptera*, associated with *Rhynchonella* sp., *Murchisonia* sp., *Isochilina grandis*, var. *latimarginata*, and *Leperditia* sp. The beds dip uniformly N. 65° W. into the lake at an angle of two or three degrees.

At a point a mile to the north these beds are hardened and very much cracked by a light anticline striking about east and west, and are overlaid by a foot or two of thin-bedded compact slate-like dolomite also holding *Strophomena acanthoptera*, which breaks into small rectangular blocks, covering the beach with a rough debris.

The porous dolomite continues to compose the shore to lat. $52^{\circ} 44'$ when there is again a sharp bend to the east.

Goose Islands.

Returning northward to Goose Islands, the north end is found to be composed of porous dolomite similar to that on the shore opposite, with a very light dip in a westerly direction, and the north end of the middle island is also composed of the same dolomite, with *Strophomena acanthoptera*, while the rest of the islands consist of sand, clay and boulders, these latter being more numerous than on any part of the shore to the north.

Further south, in lat. $52^{\circ} 42'$, the shore is composed of similar flat-lying, moderately thin-bedded dolomite, and a mile further south similar rock is again exposed on the shore, and on a horse-shoe-shaped island a mile off the shore. No fossils of any kind were found.

The shore between and around these isolated exposures was scattered with angular fragments of similar rock, and in some of these fragments were ostracods similar to those collected further north.

A short distance north of the mouth of a creek that flows from Pickerel Creek Pickerel Lake, and empties into Winnipegosis Lake in lat. $52^{\circ} 36' 46''$, the beach is composed of a light gray thin-bedded dolomite, with a dip of 2° a little south of west. The surface is undulating, rising into little rounded mamillæ. The beds vary from the thickness of paper up to half an inch, becoming virtually a slaty dolomitic shale. The colour is light gray or bluish-gray, often streaked with red or pink. It is very compact and brittle and cut by many fissures, owing to which it readily breaks into small fragments, with which the beach is thickly strewn.

Just south of the mouth of the brook a bed of dolomite half an inch Oolitic dolomite. in thickness makes its appearance, in which are many white calcareous dots, which rapidly weather out and give the weathered surface of the rock a very pitted appearance. This bed is very similar to that at Demi-charge Rapid mentioned on page 151.

Similar rock can be seen at salient points along the shore down to lat. $52^{\circ} 33' 40''$. Fossils were carefully searched for throughout, but only very obscure traces were discovered.

Thence southward to lat. $52^{\circ} 30' 30''$, the shore is low and flat, scattered with angular fragments of pink and white thin-bedded dolomite, and boulders of gneiss become much more numerous.

Here the shore bends to the west of south, parallel to the line of Vesicular dolomite. glacial transportation, but just at the bend is a low exposure of light gray and very vesicular dolomite in a bed two inches thick, dipping a little north of west at an angle of 5° . The dolomite is generally tough and compact between the vesicles, and the bed is generally darkened, possibly from the presence of a certain amount of carbonaceous material. The vesicles would appear to have been caused by the solution of crystals of common salt that have been included in the rock. No fossils could be found, and the rock is not unlike that of the *Stringocephalus* zone of the Devonian shortly to be described from other parts of the lake, but in the absence of clear evidence it will be safer to consider it as a band in the upper portion of the Silurian or near the base of the Guelph.

For the next five miles and a half towards the south, the shore is without rock exposures, and is scattered with more or less angular fragments of thin and irregularly bedded dolomite, all of which appear to be of Silurian age, no Devonian fossils being found. This tends to

support the conclusion that no Devonian strata have yet made their appearance near the lake shore to the north, as that is the direction from which boulders have been transported.

Devonian rocks.

At a rounded point opposite a long island, in lat. $52^{\circ} 26' 30''$, the beach is composed of angular debris, much of which is a light brownish-gray impure dolomite that has probably been broken from bedded rock in the immediate vicinity. It is finely crystalline and generally rather compact, though in places broken by little vesicles made by the solution of salt crystals. It does not effervesce in cold weak hydrochloric acid, but in boiling acid it dissolves readily, leaving a quantity of dark brown residue. A few obscure fossils, such as brachiopods and gasteropods, were found in it, but they were not sufficiently well preserved to determine its taxonomic position. The rock itself is somewhat similar to a bed underlying the *Stringocephalus* zone found at the base of a cliff in Dawson Bay, and which is clearly of Devonian age. Therefore as the rock is of rather peculiar character, in default of other evidence, it is here placed in the Devonian, and its parent bed is doubtless in the immediate vicinity.

Very shallow water.

To the southward the beach continues exceedingly low, and the water is so shallow that it cannot be navigated near the shore, even with a canoe, without considerable difficulty. There is no sign of the Palaeozoic rocks down to lat. $52^{\circ} 23'$, where a hill rises back from the shore to a height of thirty-five feet above the water, its lightly rounded crest being composed of more or less water-worn pebbles, chiefly of white limestone, though a few are of gneiss. On its side, sloping towards the lake, is a ridge fourteen feet above the water level, and this ridge, with the present beach, is composed almost entirely of large or small pebbles of a light brownish vesicular semi-crystalline dolomite, weathering into very typical irregular roundish nodose masses like the rock at Devil's Point. No rock was seen in place.

Island Z.

For six miles and a half further to the south the shore is very low, and scattered with loose fragments of nodose dolomite, and thin slabs of harder, more compact, probably Niagara dolomite. The north shore of Island Z, lying in north latitude $52^{\circ} 18' 30''$, appears clearly to be composed of Monroe Point beds, for while no rock is seen in place, the shore is strewn with angular masses of cream-coloured tough vesicular dolomitic limestone holding a number of fossils such as crinoid stems, *Astræospongia Hamiltonensis*, *Spirorbis omphalodes*, *Pinacotrypa marginata*, *Fenestella vera*, *F. dispanda*, *Productella subaculeata*, *Conocardium Ohioense*, *Leperditia? exigua*, and *Proetus mundulus*.

South of this island the shore is thickly strewn with boulders of gneiss and dolomite, being often backed by an ice-shoved boulder

wall, and no rock is seen in place for ten miles until latitude $52^{\circ} 10' 20''$ is reached, where a hill rises by an easy slope from the edge of the Rocky hill. water to a height of sixty feet, its sides being strewn with dead birch, spruce and poplar. Its crest is slightly rolling parallel to the shore, and is covered with pebbles and rounded cobbles, and its western face with large masses, possibly some of them being in place, of a thick-bedded light yellowish-gray porous and vesicular dolomite, in which were but few and ill-defined fragments of fossils. The rock is, however, almost precisely similar to that on the Island off Whiteaves Point in Dawson Bay, belonging to the lower part of the *Stringocephalus* zone.

Close to the edge of the water, a low cliff of a light yellow soft porous dolomitic limestone, chiefly characterised by the presence of a large number of fragments of stems, plates and pinnules of crinoids, extends for 100 yards along the beach. It is in beds of from one to three inches in thickness, and is generally horizontal, but in some places it is tilted to the south, at angles as high as eight degrees, to a light fault, beyond which the beds are again horizontal.

Five miles further south, Point Brabant overlooks the lake from Point Brabant. behind a row of large wide-spreading elms, its base being generally ten feet above the water, and its crest at its highest part twenty-six feet higher. At the first good exposure, the lower sixteen feet of the cliff consists of a hard, compact, light yellowish-gray dolomite, resounding when struck and breaking with an irregular fracture. Near the middle of this band, at nine feet from the bottom, is a thin bed of clay shale. The dolomite is not very fossiliferous, but the following species were collected from it. *Cyathophyllum vermiculare*, var. *præcursor*, Fossils. *Alveolites* like *cryptodens*, *Productella subaculeata*, *Spirifera Richardsonii*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *A. reticularis*, var. *aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus* and *Orthoceras Hindii*.

The upper ten feet of the cliff is a somewhat similar dolomite, but contains very few traces of fossils.

The beds appear to be in general horizontal, but twenty-five paces further south they are broken by a light fault with a downthrow of two feet to the north.

For the next 300 paces the beds decline slightly to the south, Section along the shore. parallel with the decline in the top of the cliff. On the beach were scattered a few fragments of a limestone conglomerate, probably from beds near the bottom of the cliff.

Point
Brabant.

In the next 110 paces the beds of dolomite dip fifteen feet to the south. In this latter stretch the beds are very hard and compact, but much broken by little joints, so that they have been worn into caverns by the waves. Some thin beds of clay run through these lower beds.

In the next fifteen paces the cliff is fifteen feet high, and the rock is considerably broken, but it appears to be rather shaly towards the top.

In the next twenty-five paces the rock dips six feet, and here shows a cliff twenty feet high, the beds being white magnesian limestone, occasionally stained with dull pink, and holding numerous *Atrypas*, &c.

At this point there is a fault with a downthrow to the south. On the opposite side of the fault twenty feet of light red and gray shale is exposed, dipping S. 25° E. at an angle of 45° .

Throughout this distance it would appear that about thirty feet in all of dolomitic limestone, and twenty feet of red and gray shale is exposed, the latter being higher than the former, and having been dropped into its present position by the last-named fault.

For about 200 paces the shore is rather low to an exposure of a yellow semi-crystalline dolomite through which are running many round tubular cavities that possibly represent natural moulds of *Pachypora polymorpha* or a similar coral that has entirely or almost entirely decayed away. The exact position of this bed remains undetermined.

For the next 240 paces the bank is composed entirely of till and boulders, and is about three feet in height. At this point it rises to a height of ten feet, consisting at the bottom of six feet of yellow argillaceous limestone, overlaid by four feet of white limestone.

For 100 paces similar rock is practically horizontal, at the end of the distance the cliff consisting of four feet of brittle argillaceous limestone, overlaid by six feet of thick-bedded white limestone.

Continuing down the shore for forty paces a sharp anticline suddenly brings up four feet of a light yellowish-red calcareous argillite.

Ten paces further the cliff is twelve feet high and is composed of eight feet of yellow and pink, hard, compact often thin and irregularly bedded argillaceous limestone, holding specimens of *Atrypa*, &c., overlaid by four feet of white thick-bedded limestone.

For the next thirty-five paces the beds are difficult to follow as they are a good deal crumpled, but they appear to have a light dip of about three feet to the north. Here there is an almost vertical fault striking S. 65° E. with a downthrow to the south, probably of not more than five feet. On the south side of it is a cliff of limestone eleven

feet in height, with the friable limestone at the bottom, while on the north side are six feet of light gray argillaceous limestone, becoming almost a clay shale at the top, where it is also of a pinkish colour.

Sixty paces further the cliff consists of six feet of hard limestone, overlaid by three feet of a light pink hard calcareous shale.

Thirty-five paces further, the section is terminated in two feet of a white thick-bedded limestone holding *Atrypa reticularis*, *Atrypa aspera*, *Paracyclas elliptica*, &c. The beds are practically horizontal, though possibly with a very light dip towards the north.

South of Point Brabant, Mr. Dowling reports that the shore is scattered with boulders, and marsh often stretches for a considerable distance inland, no rock in place being seen till Net Point is reached Net Point. in north latitude $51^{\circ} 54'$ where there is a low outcrop of three feet of cream-coloured tough dolomite dipping north at an angle of 10° . It evidently belongs to the Stringocephalus zone, and contains a few fossils such as *Murchisonia brevispira*, *Eunema turbinata* and *Macrochilina* sp.

In latitude $51^{\circ} 47' 20''$ a low exposure was also observed by Mr. Dowling below the surface of the water, but its character could not be determined.

Descending to the south end of the lake, and beginning on the South end of west side of the point west of Meadow Portage, a low anticline brings lake. a hard limestone three feet above the water, the outcrop extending seventy paces along the shore. The strike of the anticline is N. 30° W., and the dip about 3° away from the middle on each side. The rock consists of a yellow hard fine-grained semi-crystalline highly dolomitic limestone, in which are many vesicular cavities apparently caused by the former presence of crystals of common salt.

No fossils were seen except a wide-spreading Stromatoporoid, but from the position and character of the rock it is evident that it belongs to the Winnipegosan formation of the Devonian.

Five-eighths of a mile further west along the shore, a thin-bedded compact limestone is exposed for 150 feet. It has a dip of S. 55° W., exposing in all twelve feet. Averaging the dip between this and the last exposure as 4° , the total thickness of beds covered between the two points would be 230 feet. The dip may, however, not be persistent, and small faults are not unlikely to have occurred in the covered interval.

The rock is a somewhat magnesian limestone of a light gray or pinkish colour, and some of the beds contain large numbers of *Atrypa reticularis*, while *Paracyclas elliptica*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, and *Loxonema altivolvis* were also

found. It represents the lower beds of the Manitoban formation of the Devonian.

Charlie Island Four miles further west, on Charlie Island, several exposures of similar Manitoban limestone may be seen in cliffs rising at the north end to a height of ten feet, generally brought up by anticlines with an average strike of N. 45° W. The cliff at the north end of the island shows three feet of a compact, thick, and regularly bedded limestone, underlaid by nine feet of a compact but irregularly bedded limestone, which breaks readily into small fragments under the action of the water. The stratification is undulating and the main anticline runs S. 45° W., from which the beds dip outwards at first at an angle of 25° , which, however, rapidly decreases.

At the north end of a small island a few yards to the west, a cliff four feet in height shows the lowest of the above beds in an anticline striking N. 55° W., with the beds dipping at first 12° from the middle line. 300 yards further south, on the west side of Charlie Island, three feet of similar beds are exposed.

On the east side of the island several exposures of similar limestone form cliffs just behind the beach, one of which shows twelve feet of strata. They are brought up by an anticline striking N. 30° W., from the east of which the beds dip away at first at an angle of 12° .

On a small island north of Charlie Island, similar white limestone rises in little cliffs, four feet above the water.

In all these exposures fossils are moderately plentiful and among the most common are *Cyathophyllum vermiculare*, var. *præcursor*, *C. petraoides*, *Alveolites* like *cryptodens*, crinoidal columns, *Productella subaculeata*, *Strophodonta arcuata*, *Atrypa reticularis*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Euomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Orthoceras Hindii*, *Ptyctodus calceolus*.

Snake Island, Leaving Charlie Island and crossing two miles of open water in a north-westerly direction we reach Snake Island, which is a long, narrow and almost bifid island lying north and south. Beginning at its northern end and proceeding first west and then south, a cliff 10 feet high of white, thin-bedded, well stratified limestone is found to extend along the shore for 200 yards. At the east end of the cliff the beds rise from the edge of the water with a dip of 4° S. 85° E. Towards the middle the beds are more irregular and break away in small fragments, while at the west, they are even and about horizontal, and then with a light dip descend to the edge of the water.

230 paces S. 35° W. the same beds again appear on the shore and continue to rise for eighty-five paces, where the cliff is 17 feet 6 inches

in height. This point appears to be the centre of a domed anticline, as the rock dips from it in both directions along the shore, and at the same time back towards the centre of the island. Eighty-five paces further south-west along the shore the cliff is only six feet high, its base being three feet above the water, and the beds appear from the lake to be nearly horizontal, while they dip back at a low angle.

Seventy paces further a continued low dip has caused the beds to disappear below the gravel beach, four feet above the water.

In the highest part of the cliff, the bottom being about three feet above the water, the rock is a white limestone very much the same as that seen at Charlie Island. For six feet at the bottom, the beds are more brittle than those higher up the cliff, but they are not worn into little caves such as are seen at the foot of some of the cliffs on the former island. All the beds are cut by almost vertical jointage planes running from top to bottom.

The taxonomic position of the beds here seen would appear to be near the base of the Manitoban formation and a little above those outcropping on Charlie Island. A few species of fossils, such as *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica* are moderately plentiful, but with these were also found *Cyathophyllum vermiculare*, var. *præcursor*, *Alveolites vallorum*, *Orthis striatula*, *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Euomphalus subtrigonalis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Cyrtoceras occidentale*, *Gyroceras submamillatum*, *Dinichthys Canadensis*.

On the west shore of the southern expansion of the island is a low exposure of similar white thin-bedded limestone dipping regularly S. 45° W., at an angle in places as high as 30° . About twelve feet in all is seen. It contains many of the fossils mentioned above, along with *Cyathophyllum profundum* (var.), *Alveolites* like *cryptodens*, *Stromatopora Hupschii*, *Productella subaculeata*.

Snake Island is classic ground in the history of western geology. It was here that Prof. H. Y. Hind, in 1858, made the collection of fossils that first determined the existence of Devonian in Manitoba. The species then collected are all included in the above list with the exception of *Orthis striatula* which has not been found by the writer.*

In the early part of the same year Mr. A. W. Wells, acting as assistant to S. J. Dawson, visited the island and states that the rock

* See Rep. on Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, 4to, Toronto, 1859, p. 93, and App. by Mr. E. Billings, pp. 186-7.

is "a whitish limestone, full of organic remains,* but their character was not determined.

Point south of Snake Island.

Leaving Snake Island and crossing two miles of open water, a point is reached where similar white Manitoban limestone containing the same fossils, forms the beach for a short distance, dipping at an angle of 4° down to, and beneath the surface of the water.

At another point three-quarters of a mile further south similar limestone dips S. 85° E. at an angle of 5° , and three-quarters of a mile still further south at the bottom of a bay it is dipping S. 65° E. at an angle of 4° , and on a long point forming the south boundary of the bay it is dipping S. 35° E. at an angle of 7° .

The shore in this vicinity is low, and often guarded by an embankment of boulders, behind which is a broad expanse of marsh.

Two miles west of Snake Island a long point projects towards the north, and on its west side is a slight exposure of similar limestone holding some of the same fossils, and dipping S. 85° W. at an angle of 5° .

Mossy River.

The only remaining exposures discovered near the south end of Lake Winnipegosis are on Mossy River, one at the crossing of the old Canadian Pacific Railway location, a mile up from the mouth of the river, and the other a little higher up.

Pink-tinted limestone.

The former outcrop shows, for a distance of thirty-five paces on the west bank of the river, a white or pink-tinted limestone. It is thin-bedded and rings when struck with the hammer, being very similar in character to the rock seen on Manitoba Island. In the middle of the exposure it is much broken, and the fractures are often filled with crystals of calcite, but at both ends it has a fairly regular dip of 30° to 40° in a direction S. 5° W. About four or five feet in all of the rock is exposed. The beds are not very fossiliferous, the only distinguishable form being *Cyrtina Hamiltonensis*. Similar rock extends for twenty paces along the east bank of the stream, a few yards higher up. It is here dipping S. 20° E. at an angle of 8° .

From a quarter to half a mile further up the river, on the west bank, is a cliff about sixty yards long and from eight to nine feet high, consisting of white limestone similar to the last, thin-bedded, the bedding being often distinctly shown by fine lines of coloration. The face of the cliff, which runs S. 15° E., is parallel to the strike of the beds, which appear to have a dip of 12° N. 75° E., though they are very undulating. The lower beds break somewhat irregularly, and weather to a light brown. No determinable fossils were found, but the rock is

* App. (No. 36) to the 17th vol. of the Journals of the Legislative Assembly of the Province of Canada. Report of S. J. Dawson, Esq., C.E., p. 7.

doubtless of the same age as that a little further down the river, and appears to represent some of the higher beds of the Manitoban formation, such as are seen at Point Wilkins, and on some of the islands in Swan Lake.

The rest of the banks of Mossy River and the shores of Lake Dauphin are composed entirely of glacial and alluvial deposits.

From the mouth of Mossy River the western margin of Lake Winnipegosis is low, and shielded by a wall of boulders of gneiss and dolomite, behind which is a grassy meadow stretching back to a poplar forest.

At Monkman's Salt Springs, the shore is straight, and composed of small boulders and pebbles of gneiss and limestone, rising, 100 feet back from the water's edge, in a low ridge of rounded gravel, wooded with a few small willows. Behind this a grassy prairie runs N. 65° W. 460 paces, rising in the distance about eight feet. To the north is a grove of poplar and small oak, while to the south the poplar soon becomes mixed with a little spruce.

At the end of the above distance a slight grassy knoll fifty feet in diameter rises eighteen inches above the general surrounding level. In the centre of this knoll are several irregular holes surrounded by a red incrustation and filled with a clear brine, which rises from several small springs in the bottom of the holes. The springs flow in all about fourteen to twenty gallons of brine an hour, which flows out over the surrounding land and evaporates or sinks into the ground. (The temperature of the water on July 1st was 42° F., and the salinometer showed a salinity of 10 per cent.) Bubbles of colourless, odourless and unimflammable gas rise every few minutes in this spring, especially when the surrounding sod is pressed down by walking over it. The water has been analyzed by Mr. Hoffmann of the Geological Survey and found to contain 1347·08 grains of common salt to the imperial gallon.

West of the above spring is a flat, somewhat in the form of a circle, a quarter of a mile in diameter, almost totally devoid of vegetation. It is bounded on the north by open woods of poplar and oak, and on the south by a forest of spruce. On the west, in which direction the land declines very slightly, beyond two small groves of poplar is a low-lying meadow stretching to the north and south. In this meadow, half a mile from the first spring in a south-westerly direction is a small marshy lake, which stretches three-quarters of a mile to the south, and in which the water is slightly brackish. On the above arid flat are the ruins of several old houses, and lying about are a number of broken and rusted iron pans in which salt was

Monkman's
Salt Springs.

Ruins of
houses.

Monkman's
Salt Springs.
(Contd.)

formerly made for the use of the Red River settlement. Several wells have also been dug here in the clay or till, and the cribbing around them is still almost unbroken. They are now full of salt water, and in one of them, which is ten feet deep, and lying S. 65° W. from the spring above-mentioned, the water was standing at 72° F. and had a salinity of 18 per cent. This water was found by Mr. Hoffmann to contain 3099.41 grains of common salt to the imperial gallon. In another well close by, the water is 70° F., and has a per cent salinity of 6. Many shallow pits in the vicinity contain water ranging in salinity from 16 to 24 per cent, the latter being the highest, but perhaps the most common. In places where the ground has been overflowed, there is a light crust of salt on the surface.

No rock is seen in place in the vicinity of these springs, and they appear to rise through the general covering of till.

Cliff of lime-stone.

For some distance northward the shore is low and without rock exposures, the prominent points being composed of transported boulders, but in the bottom of a little protected bay in latitude $51^{\circ} 54'$ a beach of limestone pebbles, thirty feet wide, slopes up for four feet to the base of a little cliff of limestone three feet in height. The water off the shore is deep, with a soft muddy bottom.

The rock is a fine and even-grained light yellow argillaceous limestone, obscurely stratified, the layers being in the main horizontal, but locally undulating, without jointage planes, but breaking into very irregular fragments. The upper bed is hard and compact, but traversed by many thin veins of calcite, and weathers to a pure white. Below this hard bed is two feet of a yellowish soft clayey limestone, running into an irregular semi-nodular limestone.

No fossils were found, but the rock doubtless forms a portion of the argillaceous band near the base of the Manitoban formation, and underlying the limestone of Snake Island and other localities.

Gravel hook.

The north-eastern side of the bay is bounded by a hook of rounded limestone gravel, rising eight feet above the water; and extending northward is a gravel embankment, the pebbles in which become gradually coarser to a point just opposite the north end of the bay, where a thick-bedded, tough and very vesicular dolomite is exposed for two feet above the water, having a dip 7° N. 70° W., exposing in all beds to the thickness of 6 feet 6 inches.

This same band of rock again appears on the shore a short distance south of Weston Point, having there a dip of 3° to 5° in a direction S. 60° W. These two exposures belong to the *Stringocephalus* zone of the Winnipegosan formation and contain such typical fossils as *Atrypa*.

reticularis, *Pentamerus comis*, *Stringocephalus Burtini*, *Paracyclas Winnipegosan fossils*, *elliptica*, *Raphistoma Tyrrellii*, *Murchisonia turbinata* and *M. Dowlingii*.

Half-way between these two exposures is a cliff showing five feet of white limestone dipping N. 55° W. at an angle of 3° , filled with *Atrypas*, &c., and representing the lower limestone of the Manitoban formation.

To the westward of Weston Point an island, about half a mile in length extends nearly north and south parallel to the shore. Along its eastern side is a cliff ten feet in height of white thick-bedded limestone, the upper six feet being very compact and massive, while the four feet below are more friable, and break easily into irregular fragments. The bedding is almost horizontal, but undulates slightly.

On the north end of the island a cliff of similar limestone rises to a height of eight feet abruptly out of the lake, the beds dipping at an angle of 10° S. 40° W.

Both these exposures belong to the lower portion of the Manitoban formation and contain great numbers of *Atrypa reticularis* and *Atrypa aspera*, associated with such fossils as *Productella subaculeata*, *Spirifera fimbriata*, *Cyrtina Hamiltonensis*, *Pentamerus comis*, *Actinopteria Boydii*, *Modiomorpha tumida*, *Paracyclas elliptica*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Loxonema altivolvus*, *Orthoceras Hindii*, and *Gyroceras submamilatum*.

The shore from Weston Point to Red Deer Point is low, and skirted by a beach of gravel or boulders, behind which a meadow of greater or less width is usually found stretching back to a forest of spruce and poplar. East of Red Deer Point is South Manitou Island, on the shores of which are several exposures of Manitoban limestone, which may be described in detail as follows.

Near the south end of the west side of the island, at the back of a narrow gravel beach rising to a height of two feet above the lake, is a low cliff four feet high, of a white thick-bedded compact limestone, containing such fossils as *Atrypa reticularis*, *Atrypa aspera*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Raphistoma Tyrrellii* and *Loxonema altivolvus*. It is almost undisturbed and horizontal, though having a very light dip to the south, exposing in all six feet of strata in the cliff.

Opposite this point, but on the east side of the island, similar cliffs, seven feet in height, expose in all nine feet of the same white thick-bedded compact limestone. The rock strikes along the shore in a direction N. 15° W. and dips S. 75° W. at angles varying from 18° to 24° , varying a little in direction with slight irregularities in the strike. It also contains numerous fossils of the same species as those at the previous

South Manitou Island.
(Contd.)

locality, though with them are also found *Bellerophon Pelops* and *Cyathophyllum vermiculare*.

North of this cliff the shore is strewn with boulders for a short distance, and then a beach ridge of limestone gravel forms a long sweeping curve in front of a low meadow to the north-east point of the island, which is piled ten feet high with large round water-worn boulders of gneiss.

North end.

Half a mile west of this point, on the north side of the island, a light anticline with a strike N. 45° W. brings white limestone, similar to that last seen, three feet above the water, and from here westward, for a distance of about 600 paces, to the north-western angle of the island rock in low cliffs is more or less continuously exposed. It is very much tilted and broken by small faults, but the beds at the west end of the beach are of the same age as those at the east end. The strata consist at the bottom of twelve feet of thick-bedded white limestone similar to that last seen. From it the following fossils were obtained, viz.:

Cyathophyllum vermiculare, var. *precursor*, *Alveolites* like *cryptodens*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Spathella subelliptica*,

Paracyclas elliptica, *Raphistoma Tyrrellii*, *Loxonema altivolvus*,

Hyotithes alatus, *Orthoceras Hindii*, *Gomphoceras Manitobense*, *Gyroceras submamilatum*, and *Aspidichthys notabilis*. This limestone is

seen to be conformably overlaid in places by at least six feet of pink-tinted irregularly fractured very calcareous argillite more or less compact and lying in beds of varying thickness. In one place also a bed of yellow and much fractured, thick bedded calcareous argillite, or argillaceous limestone, very similar to that outcropping at the southern exposure near Weston Point, is let down by a small fault against the underlying limestone. This bed may overlie the pink argillite, and its position is probably close above the six feet of strata recorded. Five feet of these yellow beds were seen. No fossils were seen in the argillaceous zone except a few fragments of small crinoid stems. (See Fig. I plate).

Beyond South Manitou Island the shores of Sagemace Bay, and the lake to near north latitude 52° 40', are low and no exposures of the underlying rock could be found.

Birch Island.

Birch Island also has a shore very similar in character, except at its north-eastern extremity, where a little vertical cliff of Devonian dolomite, several hundred paces long looks out over the lake across a shelving beach of rounded pebbles. The top of the cliff at its highest point is level and ten feet above the water. There is here exposed in all twelve feet of yellow argillaceous dolomite in nearly horizontal beds from two to eight inches in thickness, but often broken by fractures to

Red and yellow argillite.



North End, South Manitou Island, Lake Winnipegosis

Horizontal Scale 160 ft. to an inch.

Vertical Scale 5.5 ft. to an inch.



Devil's Point . Lake Winnipegosis

Ancient cliff of porous dolomite, with red shale at water's edge.

Scale: 40 feet to an inch.

such an extent that the stratification is greatly obscured. The rock is porous and semi-crystalline, and often traversed by holes or cavities which at one time probably held fossils which have since been dissolved, and the only fossil found was a specimen of *Pentamerus comis*.

This rock usually weathers with a rough irregular knobby surface that is locally characteristic in any places where the rock is not subjected to much wear.

This Birch-Island dolomite is the lowest series of beds that have been definitely determined in Manitoba to be of Devonian age, but between them and the underlying Silurian there is a gap probably representing from fifty to a hundred feet of strata that have not yet been seen, and the country where these rocks would have been supposed to outcrop is now covered by the north-eastern portion of Lake Winnipegosis.

On Hill Island, a cliff rises at its northern end to a height of twenty feet above the top of the sloping beach of gneiss boulders, or about twenty-six feet above the surface of the lake. The cliff is behind a belt of large spruce and poplar, is not now being actively worn by the waves, and is much covered by debris, but twelve feet of the thick-bedded horizontal porous semi-crystalline dolomite was measured. South of the cliff is a tail deposit of till with striated pebbles, and on the sloping surface of this till are two deposits of rounded gravel representing stages in the recession of the water of the lake, one twelve, and the other twenty-two feet above the present surface of the lake.

Proceeding north-westward from the cliffs on Birch Island, the presence of the same beds is indicated in North Manitou Island, where large angular masses are scattered over the heap of boulders of gneiss. Similar rock is also shown to outcrop on, or in the vicinity of a hill north-west of Fox Point, where a ridge with a crest twenty-eight feet Fox Point. above the lake is largely composed of rounded masses of similar porous massive granular dolomite, in which, however, a few fossils were found, consisting of *Atrypa reticularis*, *Atrypa aspera*, *Actinocystis variabilis*, *Productella subaculeata*, crinoid stems, &c.

On the east side of Pemmican Island there is a cliff forty feet in height, situated like many of the other cliffs in this portion of the lake, behind a row of trees that here consist of poplar, elm and maple. On the top is eight feet of limestone gravel in a sandy matrix, below which is exposed sixteen feet of yellow, granular horizontal Birch Island dolomite, as in most of the other places, it appears to be unfossiliferous. From the base of the exposed cliff, sixteen feet above the water, the shore is generally covered with boulders and small stones, but under these is a compact red clay, not improbably representing

Pemmican
Island.
(Contd.)

the outcrop of a bed of soft red argillite that may form the terrane underlying the Birch Island dolomite, and if this be the case the ease with which it would yield to eroding agencies would account for its general absence in natural sections.

Lignite.

On the beach are also scattered a number of fragments of lignite, and concretionary nodules of Marcasite, but the former, and probably also the latter, are undoubtedly of Cretaceous age, and would seem to be derived from an outlier of Dakota sandstone deposited in a hollow of the Devonian rocks and protected by the shelter of the cliff from destruction in either glacial or preglacial times.

A low outcrop of rock, probably slightly higher than that on Pemmican Island, occurs on the west shore of the lake in latitude 52° 45'.

But the most interesting and instructive exposure of the rocks of Devils Point. this series is found on the west side of Devils Point, where a red clay, similar to that on Pemmican Island, makes its appearance in places close to the edge of the water, and on the beach are lying a number of spherical nodules of marcasite. The lowest beds definitely seen in place, however, are slightly undulating white porous and vesicular dolomites, regularly bedded, and containing a large number of fossils. These white dolomites are seen to have a thickness of three feet, and are probably immediately underlaid by red argillites. The following is a list of the fossils obtained from this band: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Orthis Manitobensis*, *Streptorhynchus Chemungensis*, *Spirifera Richardsonii*, *Modiomorpha parvula*, *Macrodon pygmaeus*, *Anodontopsis affinis*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Cypricardinia planulata*, *Dentalium antiquum*, *Bellerophon Pelops*, *Straparollina obtusa?*, *Loxonema gracillum*, *Hyolithes alatus*, and *Proetus mundulus*?

Conformably overlying this white dolomite three feet of yellow porous dolomite is exposed, weathering with a rough nodular surface and apparently devoid of fossils. Above this, eleven feet is covered by beach deposits and debris fallen from the cliff, which is hidden behind a row of poplars. This cliff shows twelve feet of the rough yellow porous unfossiliferous dolomite in horizontal beds, overlaid by one foot of limestone gravel. From the summit of the cliff the land rises gently for a short distance and then more rapidly to the summit of a gravel ridge forty-five feet in all above the water. The whole of the surface is underlaid by more or less water-worn fragments of the limestone of the cliff.

Grand Island. Crossing the strait to the west side of Grand Island, a cliff is also found within the edge of the timber, rising to a height of fifty feet above the water. The face of the cliff is for the most part covered with

slides and overgrown with bushes, but at its foot red clay forms a considerable portion of the shore, indicating the presence of the red argillite; the top of the cliff is composed of twelve feet of rough yellow porous dolomite, apparently quite unfossiliferous. On its summit is a gravel ridge at an elevation of fifty-five feet above the water.

On the east side of Cormorant Island a number of rounded nodules of marcasite are scattered among the gneissic boulders, having doubtless been ploughed up by the glacier from some outlier of the red argillite in the vicinity.

The last place at which this band was definitely recognized was on the eastern side of a small island lying east of Channel Island, where the ice has shoved up a large number of irregular angular fragments from the parent bed just beneath the surface of the water. It is here a rough yellow porous dolomite, the same as the higher beds at Devils Point, and like them appears to be entirely unfossiliferous.

Lying west-south-westward from the line of outcrop of the Birch Island dolomites is a belt of country, from twelve to fourteen miles in width, that lies a little higher than the country on both sides of it and possesses a much larger land area. On this higher belt rock exposures are almost entirely absent, the surface being more or less completely covered with till. The higher portion of the Winnipegosan horizon is, however, indicated by the presence of unworn pieces of dolomite, with fossils already recorded, on a small island south-east of Birch Island, and exposures of the lower portion of the Manitoban limestone are seen on the west sides of Pelican and Cameron bays. The Pelican Bay. former exposure is in latitude $52^{\circ} 44' 30''$ and consists of a cliff extending 200 paces along the shore and rising twenty-six and a half feet above the water. The rock is brought up by a low anticline striking N. 10° E. and forms a ridge that can be followed for some distance into the woods. The upper six feet is a white slightly argillaceous limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera* and *Paracyclas elliptica*, and a few specimens of *Bellerophon Pelops*, *Pentamerus comis* and *Proetus mundulus?* Below this is a yellowish and much more friable limestone, breaking into angular fragments, and apparently unfossiliferous.

The other exposure is on the west side of Cameron Bay, where a cliff rises thirty-seven feet above the surface of the lake. It is almost hidden behind a narrow belt of poplar growing on a gentle slope, which, at a height of eleven feet above the water, is piled with nine feet of irregular rock debris. Above this rises an almost vertical wall for fifteen feet, composed of light buff argillaceous limestone. It is horizontally and evenly bedded, is compact and even-grained, and breaks

regularly when struck with the hammer, the beds being very sonorous. It is very similar to the rock seen on the shore of Red Deer Peninsula, three miles south of Weston Point, and to some of the rock at Point Brabant on the east shore of the lake and represents the base of the Manitoban formation.

The lowest beds exposed in the cliff, for a thickness of three feet are very fossiliferous, and contain a great number of *Atrypa reticularis*, and crinoid stems, associated with *Cyathophyllum Athabascense*, var., *Productella subaculeata*, *Cyrtina Hamiltonensis*, *Atrypa aspera*, *Kejerteinia subovata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Orthoceras Hindii*, *Gomphoceras Manitobense*, and *Proetus mundulus*. The upper beds also contain a few similar fossils scattered through them, but not in any great abundance. The foot of the cliff is springy, and the water flowing from it is quite fresh.

Line of low country.

West-south-west of the belt of slightly higher land, which appears to be a more or less irregular broad synclinal trough, is another linear area eroded out into rather deep hollows, which on the map can be traced through the western and north-western arms of Lake Manitoba, through the open part of Lake Winnipegosis between Red Deer Point and Birch Island, and onward through Pelican Lake and Dawson bays. This area contains by far the greatest number of rock exposures in the whole district. Those in the most southern portions have already been described, and while several were reported on Pelican Lake, it was found impossible to visit them. Those on Dawson Bay therefore alone remain to be described, and on account of the irregular and almost unconnected character of the outcrops it will be impossible to describe them otherwise than in geographical succession.

Dawson Bay.

Island north of Whiteaves Point.

Beginning on the east side of the bay the most conspicuous feature is an island a mile and a half north of Whiteaves Point which rises abruptly out of the lake. On the west side of this island the waves beat against the foot of a vertical cliff of white dolomite that overlooks the lake, with a total height of forty-one feet. Its summit is rough and broken, and apparently water-worn, with a covering of moss along the front, while further back, where the surface is two or three feet higher, it is covered with a thick growth of choke cherry, ash-leaved maple, &c. From here the surface declines to the east side of the island, and at length drops in a low cliff to the water. Towards the south the surface slopes gradually to the water's edge and the island termi-

nates in a bar of irregularly rounded gravel extending towards the south-west.

The cliff, shown on the plate in front of this report, is composed of Cliff of dolomite. a very thick-bedded or massive white exceedingly tough dolomite, occasionally somewhat crystalline, but never harsh or rough. The bedding is not always distinctly marked, but the hill is clearly shown to be brought up by a rather sharp anticline with a strike S. 85° W., and the rock dips off towards each end at angles varying from 25° to 30°. In the middle of the cliff, where the stratification is horizontal, thirty-nine feet of rock in all are seen. The rock is cut by numerous jointage planes that run from the top to the bottom of the exposure. A number of faults have occurred along these jointage planes, so that it is difficult to measure the exact thickness of beds exposed. If these faults were left out of account, the total thickness of strata, here seen, would be 100 feet, but it is doubtful whether a much greater thickness is brought under observation than the thirty-nine feet occupying the middle of the cliff. The thickness of beds exposed may, however, amount to fifty or sixty feet.

The lowest beds, about ten feet in all, are not so thick-bedded as the rest, break down more readily, and contain a large number of stems of Crinoids. Above this are ten feet rather barren of fossils, and then there is a very massive band from which large angular masses have fallen and are lying at the foot of the cliff. This band is rather rich in fossils, Fossils. and from it the following species have been collected: *Sphaerospongia tessellata*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Alveolites* like *cryptodens*, *Stromatopora Bücheliensis*, *S. Hüpschii*, *Ctenocrinus* sp., *Spirorbis omphalodes*, *Pinacotrypa marginata*, *Cystodictya Hamiltonensis*, *Fenestella vera*, *F. dispanda*, *Polypora Manitobensis*, *Productella subaculeata*, *Orthis Manitobensis*, *Streptorhynchus Chemungensis*, *Strophodonta intertrialis*, *Strophodonta arcuata*, *Spirifera fimbriata*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Nucula Manitobensis*, *Dentalium antiquum*, *Pleurotomaria Spenceri*, *Euomphalus annulatus*, *Platyceras parvulum*, *Orthoceras Tyrrellii*, *Gyroceras filitextum*, *Isochilina Dawsoni*, *Elpe Tyrrellii*, *Bronteus Manitobensis*, *Cyphaspis bellula*, and *Proetus mundulus*.

Whiteaves Point is a cliff twenty-one feet in height extending Whiteave Point. for a mile along the shore, and rising to a total height of thirty-one feet above the water. In front of it is a strip of land fifty feet in width wooded with fine large elms, between which and the water is a low beach of irregular fragments of limestone. The summit of the cliff is rather rough and wooded with small poplar.

The rock is a white compact, uncrySTALLine, dolomite not very thickly or evenly bedded, but breaking readily into irregular fragments. Though the stratification is essentially horizontal, it is cut by numerous jointage planes, along which the rock appears to have slidden to some extent. It probably represents the highest beds seen at the island just described, or possibly beds somewhat higher.

In places it contains a large number of beautifully preserved fossils, among which the most common and conspicuous are *Stringocephalus Burtini*, *Orthoceras Tyrrellii* and *Gyroceras Canadense*. With these are associated many of the species found at the small island, and in addition the following species : *Cyathophyllum Anna*, *Actinocystis variabilis*, *Actinostroma Tyrrellii*, *Atrypa aspera*, *Pterinea lobata*, *Modiomorpha attenuata*, *M. compressa*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Orthonota corrugata*, *Pleurotomaria goniostoma*, *Murchisonia Dowlingii*, *Bellerophon Pelops*, *Eunema brevispira*, *Astralites fimbriatus*, *Omphalocirrus Manitobensis*, *Naticopsis inornata*, *Hyolithes alatus*, and *Homaloceras planatum*.

Islands south-west of Whit-eaves Point.

South-west of Whiteaves Point are a number of lovely wooded islands rising out of moderately deep water, on several of which exposures of dolomite and limestone are to be seen. The first of these lies a little more than a mile from the point, on the north end of which is a hill twenty feet in height. This hill is largely covered with an herbaceous growth, but an irregular rocky knob shows it to be composed of cream-white dolomite containing a great number of masses of *Actinostroma expansum*; and at the edge of the water is a more or less thin and regularly bedded hard white dolomite, poor in fossils, though containing some very large stems of Crinoids. The stratification appears to be essentially horizontal, though the more massive portions in the hill are much shattered, probably by a small fault, so that it is difficult to detect any stratification. Large Crinoid stems and the tail of a *Proetus* were found in these beds.

The shore on the north end consists of fragments of dolomite broken by the ice from the rock immediately below it, behind which are rough irregular masses fallen from the crag. The rest of the island is surrounded by a beach of more or less rounded fragments of dolomite entirely or almost entirely derived from the rock of the island itself, and containing the following fossils, viz.: *Sphaerospongia tessellata*, *Cystiphyllum profundum*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Orthis Manitobensis*, *Strophodonta intertrialis*, *Spirifera fimbriata*, *Cyrtina Hamiltonensis*, *Atrypa reticularis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Myalina inflata*, *Macrodon pygmæus*, *Orthonota corrugata*,

Pleurotomaria Spenceri, *Eunema speciosum*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Platyceras parvulum*, *Macrochilina subcostata*, *Bronteus Manitobensis*, and *Cyphaspis bellula*.

A mile further west lies a somewhat larger island, on the north-west side of which an abrupt vertical cliff of light grey dolomite, with a slightly porous and semi-crystalline texture, rises to a height of forty-three feet above the water. It is eaten out by the waves to a height of ten feet, and above is covered with light brown lichen. The foot of the cliff is covered with large angular blocks fallen from its face, while the summit is overgrown with grass and small sage-bush.

The rock is brought up by a rather sharp anticline with a strike N. Anticline. 40° E. At the eastern end is a fault with a dip of 40° striking N. 35° E., and with a throw to the north probably of about ten feet. West of this the rock rises with a dip of 27° , which rapidly lessens till in the middle and highest part of the cliff the stratification is practically horizontal. To the south the beds are cut off abruptly by a fault, south of which for seventy-five feet the beds are very irregularly disposed, and beyond which they disappear. There would appear to be a light throw to the south in this latter fault.

In the middle of the cliff the lower beds are white dolomite, thinly and more or less irregularly bedded, and apparently not containing many fossils. Above this is a similar but thick-bedded dolomite containing numbers of *Actinostroma fenestratum*. The broken dolomite to the south of the fault is of a slightly yellow colour, and from it the following fossils were obtained : *Sphaerospongia tessellata*, *Actinocystis variabilis*, *Favosites Gothlandica*, *Pachypora cervicornis*, *Alveolites vallorum*, *Ctenocrinus* sp., *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Pterinea lobata*, *Myalina inflata*, *Goniophora perangulata*, *Pleurotomaria Simpsoni*, *Murchisonia turbinata*, *M. Dowlingii*, *Porcellia striata*, *Eunema speciosum*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Pseudophorus tectiformis*, *Loxonema cingulatum*, *Cyrtoceras occidentale*, *Gyroceras Canadense*, *Cyphaspis bellula*, and *Proetus mundulus*.

To the west of this island lie two other small islands thickly wooded with elm and poplar. Both are low and no rock is seen on them in place, but on the north side of the larger one the pebbles are angular, and little, or not at all, rounded by the water, and would appear to have been shoved up by the ice from a bed of rock beneath the surface of the water. Behind the beach they are piled into a high ridge by the ice. These pebbles consist of white dolomite like the last, and contain quite a large number of the same fossils. On the east side of the island the

Islands of
pebbles.

pebbles are much more rounded, and are piled in a ridge ten feet in height by the combined action of waves and ice.

A mile south of the last rocky island is a larger island on the north-east side of which is a vertical cliff twenty-five feet high from top to bottom, the latter being some distance back from the then level of the water and about two feet above it. The crest of the hill is three feet above the brow of the cliff and is wooded with small poplar. The rock is a cream-white vesicular dolomite, and in places appears to be largely made up of *Actinostroma fenestratum*, *Actinostroma Tyrrellii* and *Stromatopora Bücheliensis*? Besides these, twenty-three other species were collected similar to those found at the previously described exposures in the bay, and characteristic of the *Stringocephalus* zone. The bedding in several places appears to be approximately horizontal, but it is cut by several jointage planes along which slight faults have occurred. It is impossible to say how much rock is exposed, but possibly not much more than twenty-five feet.

Beardy
Island.

Adjoining this island is a large boot-shaped island, the largest island in the bay, known as Beardy Island. On its south shore, close to the margin of the lake, a soft, cream-coloured, porous, saccharine dolomite is seen apparently in place, and large angular blocks of the same dolomite are piled on the shore. It is thick and more or less irregularly bedded, and the only fossil detected was a large nodose Stromatoporoid. This bed would appear to represent the top of the Winnipegosan series, for on the opposite side of the island, and but a short distance away, a hill rises to a height of twenty feet, on the face of which, just within the edge of the woods, is a cliff sixteen feet in height. This cliff, and the gently sloping beach of shelving rock at its foot is composed of thin-bedded white argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with the following other fossils, viz.: *Paracyclas elliptica*, *Kefersteinia subovata*, *Raphistoma Tyrrellii*, *Porcellia Manitobensis*, *Euomphalus subtrigonalis*, *Hyolithes alatus*, crinoid stems, and *Cyathophyllum Waskasense*. The bedding is nearly horizontal, and the rock overlies the harsh dolomite seen on the south side of the island and represents the lower portion of the Manitoban series.

Turning now into the bay south-west of Beardy Island, the south shore is generally low and scattered with irregular fragments of limestone and dolomite, while long bars composed of similar pebbles run out into the shallow water.

Near Bell
River.

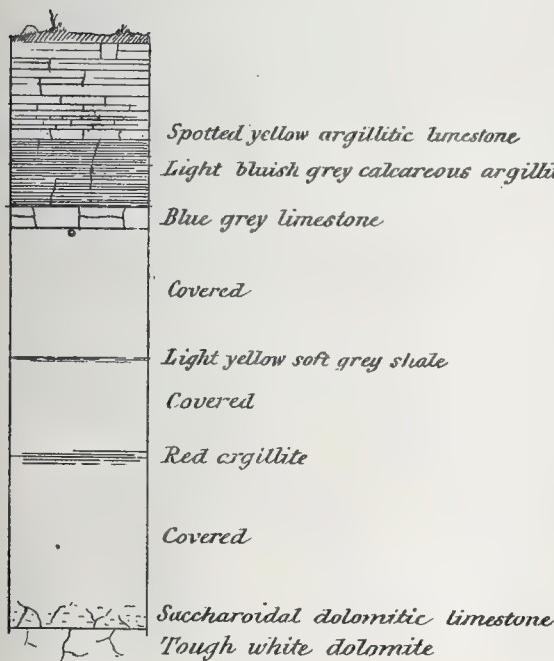
Towards the west end of this shore, and a mile east of the mouth of Bell River, a cliff from twenty to twenty-five feet in height extends for a quarter of a mile within the edge of the woods, but so much debris

has fallen and covered its face, and it is so thickly overgrown with trees and bushes that it is difficult to determine accurately the thickness of the beds composing it. However, the following characters were observed. The hill is caused by the bulging up of the rock shown by a light dip away from the centre in three directions, while the lake has cut across the front and obscured the dip that may exist towards the north.

At both ends of the cliff the upper beds are composed of light gray Argillaceous slightly argillaceous limestone containing a large number of *Atrypa reticularis* and *Atrypa aspera*, associated with *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Euomphalus subtrigonalis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Actinoceras Hindii*, and *Alveolites Ræmeri*. These represent the beds seen at Beardy Island, and eight feet or more are here exposed. They are underlaid by seven feet of a rather soft light bluish-gray calcareous argillite, in which are little masses of soft hematite, possibly caused by the decay or alteration of crystalline aggregates of pyrite. The argillite is cut by occasional veins of finely crystalline calcite, and towards the bottom contains a few nodules of hard limestone, while a foot at the top is generally harder than the rest. It appeared to be quite unfossiliferous. Its exposed face is weathered with smoothly rounded contours, and the debris falling from this portion of the cliff breaks into thin shaly fragments.

Contact of Manitoban and Winnipegosan

Formations near the mouth of Bell River.



This band is underlaid by two feet or more of a light bluish-gray unfossiliferous limestone.

Below this, the section is obscured for twelve feet by slides and vegetation, and then a light yellow soft gray clay is seen cropping from the side of the bank. It is again covered for nine feet, and then there is a slight exposure of a rather soft red calcareous argillite.

Below this outcrop of red argillite the hill is covered by debris for sixteen feet to the top of

Vertical Scale 20 feet 1 inch.

the low beach, where a yellow, saccharine, porous dolomitic limestone makes its appearance for a short distance, and from which flow springs of strong brine.

Below the saccharine dolomitic limestone, and right on the margin of the lake is a light brown or almost white, very slightly crystalline and tough dolomite. It is generally compact, but in some places is slightly porous, while in others it shows little rectangular cavities left by the solution of tabular crystals of salt. This dolomite did not appear to contain any fossils, but it and the saccharine dolomitic limestone undoubtedly represent the top of the Winnipegosan formation, while the argillite above represents the base of the Manitoban.

Contact of
Manitoban
and Winni-
pegosan
formation.

On a long point, a mile further towards the north-west, a low exposure of rather granular vesicular dolomite of the Winnipegosan formation outcrops with a dip of 5° S. 35° W., and behind it the point is heaped high with irregular fragments which have doubtless been recently broken from the rock, and shoved up by the ice. These contain a few fossils, such as *Pentamerus comis*, *Stringocephalus Burtini*, *Eunema brevispira*, &c. Proceeding S. 30° W. down the shore for 500 feet, white, friable, argillaceous limestones holding *Atrypa reticularis*, *A. aspera*, *Bellerophon Pelops*, *Hyolithes alatus*, &c., make their appearance dipping S. 75° W. 25° , and from this point they form a low cliff a little back in the woods, running southward for a quarter of a mile parallel to the shore, where it flattens out. These represent the several beds recorded in the section on the preceding page.

On the opposite side of the little bay at the mouth of Bell River, a hill rises to a height of 100 feet above the water, and across the end of this hill the waves have cut a cliff thirty feet high. The upper twelve feet of this cliff is composed of white, friable limestone, the same as that outcropping across the bay. It contains the following fossils : *Atrypa reticularis*, *Spirifera Richardsonii*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *Hyolithes alatus*, *Gomphoceras Manitobense*, *Favosites Gothlandica* and *Alveolites vallorum*.

For eighteen feet below this, in the middle of the anticline, the section is covered with debris and overgrown with brush.

A light dip carries the beds up and back from the face of the cliff, but the beds on the top of the hill are still a little higher and are composed of hard gray limestone containing a large number of *Atrypa reticularis*, *Atrypa aspera*, and *Paracyclas elliptica*.

Two miles and three-quarters north of the mouth of Bell River is a bare flat, over which a small brook flows into the lake, behind which

are some ridges of impure sand. The creek when examined on the 1st of August, 1889, was flowing sixty gallons a minute and the water was very saline, containing about six-sevenths of a pound of common salt to the gallon, which would give a total discharge by the brook of about thirty-seven tons of salt every twenty-four hours. The summer of 1889 was a particularly dry one and during ordinary seasons, with an average amount of rainfall, the brine would doubtless be somewhat weaker, but on the other hand the quantity of brine discharged and probably of salt also would be greater. This brook flows from several springs a mile or more further inland, which are described elsewhere.

A mile east of the mouth of the briny creek, on the west side of a point, is a low exposure of from fifteen to twenty feet of white porous and vesicular dolomite dipping N. 70° E. at angles varying from 0° up to 12° . It contains a few characteristic Winnipegosan fossils, and a small amount of brine is flowing from it. On the east side of the point a low anticline forms a hill thirty feet in height, the rock dipping southward at an angle of 15° and northward at an angle of 3° . The bottom beds are hidden by debris, but at the top twelve feet are seen consisting of gray limestone containing fossils, overlying nine feet of evenly bedded, light yellow limestone holding a few Atrypas, which again overlies a light blue-gray shale. The fossils in the upper band consist of *Cyathophyllum Anna*, *Atrypa reticularis*, *Atrypa aspera*, *Productella subaculeata*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, and *Gyroceras Canadense*.

North and east of this cliff the shore is generally low and the land behind it rises gently to a few feet above the water. In some places a wall of boulders lines the shore. No rock is seen in place, but brine springs rise to the surface, apparently through a light covering of till, and many of the boulders and masses of rock in this vicinity are composed of *Stringocephalus* dolomite.

Three miles north of Salt Point, an island about a mile in length, and of a somewhat oval shape, rises conspicuously out of the lake. The south and west shores of this island are composed of well rounded water-worn pebbles of dolomite, while to the north, and hidden behind a belt of trees, is a rather broken cliff twenty feet high composed of a thick and thin-bedded, coralline, dolomitic limestone cut by a number of jointage planes generally at a high angle to the horizon. The rock appears to be brought up by a light anticline and in places is composed largely of *Cyathophyllum profundum*. With this are associated *Sphaerospongia tessellata*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *Fenestella vera*, *Polypora Manitobensis*, *Atrypa*

reticularis, *A. aspera*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Eunema brevispira*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Naticopsis inornata*, *Macrochilina subcostata*, and *Proetus mundulus*.

This evidently represents a portion of the Winnipegosan formation, and probably is at the base of, or just below the bottom of the Stringocephalus zone.

Salt Point.

Returning to the north shore of Salt Point Peninsula and proceeding westward, the first exposure is a cliff thirty feet in height, which consists of white dolomite dipping a little west of south at an angle of 5°. At the water's edge it consists of a tough, white, yellow-weathering, thick-bedded dolomite, in which are many pores and vesicles surrounded by light brownish stains. The surface of the individual beds is very irregular, and in them *Actinostroma Tyrrellii* and *A. fenestratum* are very abundant, along with many other fossils. Overlying the beds above described there are fourteen feet of very similar dolomites, about the middle of which is a band containing a large number of *Kefersteinia subovata*. Besides the above, these rocks contain the following fossils, characteristic of the Stringocephalus zone of the Winnipegosan formation, viz.: *Sphaerospongia tessellata*, *Columnaria disjuncta*, *Pachypora cervicornis*, *Alveolites vallorum*, *Actinostroma Tyrrellii*, *A. fenestratum*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Gosseletia* sp., *Myalina inflata*, *Modiomorpha compressa*, *M. parvula*, *Goniophora perangulata*, *Nucula Manitobensis*, *Kefersteinia subovata*, *Paracyclas antiqua*, *P. elliptica*, *Conocardium Ohioense*, *Cardiopsis tenuicostata*, *Cypricardella bellistriata*, *Dentalium antiquum* (?), *Pleurotomaria goniostoma*, *P. infranodosa*, *Raphistoma Tyrrellii*, *Murchisonia turbinata*, *M. Dowlingii*, *Eunema speciosum*, *E. brevispira*, *E. subspinosum*, *E. clathratulum*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Pseudophorus tectiformis*, *Naticopsis inornata*, *Macrochilina subcostata*, *M. pulchella*, *Hyolithes alatus*, *Orthoceras Tyrrellii*, *Tetragonoceras gracile*, and *Proetus mundulus*. Above these fossiliferous beds the strata become thinner and much more compact to the top, where, for three feet, they are very resonant and appear to be destitute of fossils.

Half a mile farther west, is a bare cliff fourteen feet in height, consisting of a white or cream-coloured, tough, uncryocrystalline dolomite with a great number of small vesicular cavities, and containing very many beautifully clear crystals of calcite. It also contains many concretions, which in places are very small, and give the rock quite a pisolithic

appearance. This is overlaid by a bed of hard argillaceous limestone. These beds dip with considerable regularity S. 60° W. at an angle of 3°.

Behind the point formed by this projecting cliff, a hill rises to a height of seventy feet above the lake, and in a bay to the west, where this higher hill approaches close to the shore, the top of the porous dolomite outcrops on the beach. The section shown on the face of this hill is as follows in descending order :—

	ft. in.
Light gray thick-bedded argillaceous limestone, holding <i>Atrypa reticularis</i> , <i>A. aspera</i> , and <i>Paracyclas elliptica</i> in great abundance, associated with other species common to the Manitoban formation....	12 0
A very compact, fine-grained, hard, brittle buff-coloured limestone.....	1 6
A light bluish-gray, soft, fine-grained calcareous argillite, breaking down into a gray shale.....	3 0
Brownish-gray, hard, finely crystalline argillaceous limestone, through which run veins of crystalline calcite	4 0
Covered.....	8 0
Similar hard argillaceous limestone.....	3 0
Covered	36 0
Hard argillite.....	2
Porous white dolomite	

A mile and a half further west a cliff rises to a height of twenty-four feet above the water, composed of tough, white, vesicular dolomite containing *Stringocephalus Burtini* and other associated fossils ; and just at the point in which this cliff terminates, a grassy hill rises in a steep slope to a height of forty feet above the lake, and from the top, and sides of this hill flow several brine springs, aggregating in all about twenty-five gallons a minute.

At a salient point still further west, and just opposite the mouth of Steep Rock River, is a cliff of similar tough, white, vesicular dolomite, the little cavities being arranged in horizontal layers and containing a few fossils, such as *Pentamerus comis*, &c.

This cliff is twenty-four feet in height and is overlaid by a coarse saccharine dolomite, while at the foot of the cliff the rock contains *Stringocephalus Burtini* and a large number of fossils generally associated with it.

About the middle of the exposure, a slight anticline brings a light brown argillaceous and slightly crystalline dolomitic limestone just above the surface of the water. It breaks readily with a very uneven, jagged fracture, and contains a few fossils, among which are *Atrypa reticularis* and *Spirifera fimbriata*.

Steep Rock
River.

Crossing the little bay to the west, and ascending Steep Rock River for about half a mile from its mouth, a thin and evenly bedded, light brown, argillaceous limestone of the lower portion of the Manitoban formation outcrops in the bottom of the brook and for a few feet up the side of this bank with a light north-westerly dip.

Portage.

Leaving the river at this point a portage strikes off towards the south-west and passing through a poplar forest for a mile and a quarter again reaches the river in a wide marsh. Towards its western end it passes over a rocky hill that rises 100 feet above the lake, on the sides of which are several low exposures of a coarse-grained, crystalline, mottled white and brown limestone. No fossils were found in it, but it doubtless belongs to the Manitoban formation. The limestone lies in thick horizontal beds which are cut by a number of veins of crystalline calcite, and has much the appearance of some of the bands of limestone below the *Atrypa* band. It is possible that it has here replaced the shale to a considerable extent.

Hill north of
Steep Rock
River.

North of the mouth of Steep Rock River a hill rises to a height of eighty feet, with a smoothly rounded top composed of thin-bedded, horizontal, light gray Manitoban limestone, holding *A. reticularis*, &c., while twenty feet below it a spring of brine flows from the side hill and forms a barren, sterile band to the bottom of the slope. Irregular fragments of Winnipegosan dolomite are lying about, evidently derived from the immediate vicinity.

Also three-quarters of a mile north of the mouth of Steep Rock River a hill fifty-five feet in height forms a salient point projecting into the lake. On its summit are ten feet of horizontal, white, or light yellowish-gray limestone, containing a number of typical Manitoban fossils, including *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Hyolithes alatus*, &c. This is underlaid by a light gray or greenish-gray, calcareous argillite which appears to have a thickness of twelve feet or more, and below this the hill is covered to the bottom. At the north end of the hill these rocks have a dip of 20° S. 10° W. At the edge of the water is an irregularly bedded, rather coarse-grained, saccharine limestone, dipping at about 5° from N.E. to E. In places it is pure white and in other places it is of a dark brownish colour, and through it rise a number of springs of brine.

Half a mile further north a similar hill rises to a height of thirty-five feet above the lake, on the summit of which are twelve feet of typical light greenish-gray Manitoban limestone in beds of varying thickness and containing a large number of characteristic fossils. Below it is a calcareous argillite in thin beds.

Leaving the bay into which Steep Rock River empties, and coasting northward beside a long gravel spit, a hill is reached rising to a height of forty feet above the water, its lakeward face being now for the most part overgrown with bushes, and separated from the pebbly beach by a narrow belt of trees. The rock throughout is a light gray, thick-bedded, friable limestone which in places is oolitic and contains many comminuted fragments of fossils, but the only fossils that could be recognized were *Atrypa reticularis*, *Athyris vittata* and *Cypricardinia planulata*. The rock is undoubtedly the same as the upper beds at Point Wilkins, described below.

Two miles further to the north the shore turns abruptly westward, Point Wilkins and at the salient angle thus formed, Point Wilkins rises as a vertical cliff to a height of eighty-three feet above the lake, being the highest and most conspicuous promontory on its shore.

It consists of horizontal strata with the following characters, considered in descending order :—

Forty feet of light gray, very compact, fine-grained, thick-bedded, and in places oolitic limestone which breaks readily into polygonal fragments when struck with a hammer. Very few species of fossils were found in these beds, the most common being *Athyris vittata*, and with it are associated a few specimens of *Atrypa reticularis*.

Thirty-three feet of a light gray argillaceous limestone, running down into a hard, compact, sonorous limestone, interbedded with clay shale. This limestone contains, in places, beautifully preserved cubical crystals of pyrite, which disappear on weathering, leaving the surface pitted with small cavities. The argillaceous limestone and the shaly bands contain many beautifully preserved fossils, among which are *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Paracyclas elliptica*, *Euomphalus subtrigonalis*, *Gomphoceras Manitobense*, and *Ptyctodus calceolus*.

Ten feet of red calcareous argillite without fossils.

These beds represent the upper portions of the Manitoban formation as seen in this district, and although they were not seen in direct contact with the lower portion of the terrane, the red argillite at the base of the section probably lies not far above the limestone seen on the tops of the hills a little distance further south.

The highest part of the promontory is at its north-eastern extremity, from which the summit declines with a slope about a mile in length both to the south and west. The stratification is in general nearly horizontal, and the slope of the surface is formed by the unequal erosion of the beds.

The strata, however, have been cut by vertical fissures in a number Fissure of places, and into these fissures the overlying and surrounding rock breccias.

has fallen in a confused and irregular mass. One of the most interesting examples of these broken strata occurs three-quarters of a mile south of the point, where the cliff is but eighteen feet in height and hidden behind a row of birch and poplar. For a distance of thirty-two paces along the shore the rock is very much disturbed, and projects thirty feet beyond the rest of the cliff, which consists on both sides of the lower argillaceous limestone lying quite horizontally. In the disturbed portion, however, the rock consists to a considerable extent of the upper limestone holding *Athyris vittata*, in fragments lying in every conceivable position. With this limestone is associated a hard, light blue sandstone composed of fine, more or less rounded grains of white quartz, of about equal size, with occasionally an included nodule of iron pyrites. This sandstone often forms the matrix of a breccia, in which are included the angular pebbles of brittle limestone.

This brecciated mass has undoubtedly been formed by the falling in of the overlying rock to fill a cave or fissure, and the presence of the *Athyris* limestone shows that this caving in took place before the surface was denuded down to its present level, since the cliff, to its summit, is now composed of the underlying argillaceous limestone, and the presence of the sandstone shows that this limestone was overlaid by a white or light blue sand, which would appear to have been the Dakota sandstone of the base of the Cretaceous, and which was sufficiently soft and incoherent to run down and fill the interstices between the fragments of limestone. This sand has since been converted into a hard sandstone by the infiltration of a calcareous cement.

About two hundred paces further north the rock in the cliff is again disturbed in a somewhat similar manner, but here there is no sandstone mixed with the limestone.

Dakota sand-stone.

Buttress of broken lime-stone.

Half a mile still further north a mass of slidden limestone is standing like a buttress against the face of the cliff, which is here about seventy feet high. This cliff is depicted on page 67 of Dr. Spencer's Report. The beds, especially the upper ones, are but very little disturbed, and practically horizontal, while at the bottom are ten feet of evenly stratified red argillite. All are hidden for a short distance by the mass of limestone fallen from above. This has evidently been formed by the filling in of a cave from above, or of a fissure running parallel to the present face of the cliff, and on account of the inclined position of the rock, the waves of the lake, both at its present and during its higher stages, have not been able to wear it back as rapidly as the adjoining horizontal beds of the cliff, and thus it stands out as a salient feature on the face of the escarpment.

In other places in the same promontory the beds are similarly disturbed, but the instances already described are the most remarkable.

From Point Wilkins no rock in place was seen on the shore for several miles, until a little peninsula was reached just south of the mouth of Red Deer River, where the beach is composed of dolomite dipping N. 85° W. at an angle of 10°. At the back of the beach, and at the edge of the woods of elm and willow, is a little cliff, a foot or so in height, of hard white vesicular Winnipegosan dolomite, and piled up in front of it, and hiding the cliff in many places, are fragments of the same rock containing *Sphaerospongia tessellata*, *Pachypora cervicornis*, *Atrypa reticularis*, *Rhynchonella pugnus*, *Pentamerus comis*, *Stringocephalus Burtini*, *Myalina inflata*, *Kefersteinia subovata*, *Mecynodon* like *Eifeliensis*, *Cardiopsis tenuicostata*, *Cypricardinia planulata*, *Orthonota corrugata*, *Palaeacmea cingulata*, *Pleurotomaria goniostoma*, *P. infranodosa*, *P. Spenceri*, *Eunema brevispira*, *E. subspinous*, *E. clathratulum*, *Astralites fimbriatus*, *Omphalocirrus Manitobensis*, *Macrochilina subcostata*, *Orthoceras Tyrrellii*, *Cyrtoceras occidentale*, and *Gyroceras filitextum*.

Two miles and a half north-east of the mouth of Red Deer River a slight and rather irregular anticline brings to the surface twenty feet North of Red Deer River. of a thick-bedded, porous, yellow-weathering dolomite of the Winnipegosan series, containing a few very characteristic fossils, such as *Sphaerospongia tessellata*, *Columnaria disjuncta*, *Amplexus* or *Diphyphyllum*, *Pachypora cervicornis*, *Alveolites vallorum*, *Discina* sp., *Orthis Manitobensis*, *Spirifera fimbriata*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Actinopteria Boydii*, *Myalina trigonalis*, *Modiomorphia parvula*, *Paracyclas antiqua*, *Pleurotomaria infranodosa*, *P. Spenceri*, *Eunema subspinous*, *Straparollina obtusa*, *Naticopsis inornata*, *Gyroceras filitextum*.

Two miles further north a prominent point on the shore is formed of similar dolomite, also brought up by an anticline striking north and south. At the east end of the cliff the dip is eastward with an angle of 20°, while at the west end it is westward at a low angle. The rock contains *Stringocephalus Burtini* and many other fossils, the same as those found at the last point, besides which were *Polypora Manitobensis*, *Spirifera Richardsonii*, *Atrypa aspera*, *Spatella subelliptica*, *Dentalium antiquum*, and *Murchisonia Dowlingii*.

A mile and three-quarters west of this point and close to the shore, a hill of similar dolomite containing *Stringocephalus Burtini*, &c., rises to a height of twenty feet above the lake, and a mile to the north-west is another hill of very similar vesicular dolomite, which, however, did not appear to contain any fossils. Ten feet in all of

this dolomite was seen, and in a bed eight feet below the top are many little crystalline masses of pyrite, some of which have been altered into hematite. A beautiful cast of the exterior of a large salt crystal was also seen.

Below this bed of dolomite a gently sloping hill fifteen feet in height reaches to the lake, and over it are trickling several little rills of brine.

Macoun Point.

The only other exposure of rock in place, seen on the west shore of Dawson Bay is at Macoun Point, which is marked by a beautiful grove of tall spreading elms. Around the grove is a beach of rounded limestone gravel, and in front of, and a little below the gravel is a line of transported boulders of gneiss and limestone. From this line of boulders the shore extends with a gently declining slope to the edge of the water and is strewn with angular fragments of porous dolomite which have been shoved up by the ice from a bed with a very irregular surface, that makes its appearance in extreme low water in a few places. It consists of a thick-bedded, light brownish-gray, saccharine dolomite, so porous as to feel very light. It does not appear to contain any fossils, but closely resembles in general character the dolomite from Devils Point. It would seem to be an upward continuation of the Birch Island dolomite, probably immediately underlying the *Stringocephalus* zone.

Rowan Island.

Turning now to Rowan Island, which lies two miles and a half off the shore, in the north-western portion of Dawson Bay, its western extremity is found to be composed of a rough porous dolomite precisely similar to that at Macoun Point, and like it quite unfossiliferous.

Near the south point of the island this dolomite again composes the shore, while just back from the margin of the lake, a hill rises to the height of twenty feet and is composed of a white, thick-bedded, tough, vesicular dolomite, practically horizontal, and thus immediately overlying the hard porous dolomite. It would appear to represent the base of the *Stringocephalus* zone and contains a number of its typical fossils, such as *Sphaerospongia tessellata*, *Actinocystis variabilis*, *Actinostroma Tyrrellii*, *A. fenestratum*, *Cystodictya Hamiltonensis*, *Fenestella dispanda*, *Spirifera fimbriata*, *Atrypa reticularis*, *Pentamerus comis*, *Stringocephalus Burtini*, *Goniophora perangulata*, *Bellerophon Pelops*, *Porcellia Manitobensis*, *Omphalocirrus Manitobensis*, *Loxonema altivolvis*, *L. priscum*, *L. cingulatum*, *Bronteus Manitobensis*, and *Lichas (Terataspis) sp.*

For the rest the island appears to be composed of these two kinds of dolomite, though at the north end, where low hills occur, their faces are so thickly piled with boulders that the rock itself was not exposed.

Leaving the shore of Lake Winnipegos, and ascending the Red Deer River, its banks are low and alluvial for the first two miles from the lake, at the end of which distance a bare stony hill rises to about twelve feet above the river. Springs of brine issue from the top of the knoll and flow down its sides, discharging in all from one to two gallons a minute. Close to the river is a sloping exposure of rather thin-bedded, light gray, Manitoban limestone breaking into very irregular fragments and holding great numbers of *Atrypa reticularis*, with *Paracyclas elliptica*, *Cyrtina Hamiltonensis* and many other fossils. The beds are dipping east at an angle of 15° , and not more than four or five feet in all are exposed.

A short distance further up the river, on the same side, is a hill consisting of eleven feet of limestone overlaid by six feet of unstratified till. The rock is gray, yellow weathering limestone of the Manitoban series, and dips N. 60° E. at an angle of 16° . The upper five feet is a whitish limestone breaking readily into fragments and containing a number of fossils; while below it is a thicker-bedded, but not very compact, argillaceous limestone, containing but few fossils.

A little further up the river, and about half a mile above the lower salt spring, a cliff of limestone rises to the height of twelve feet above the water, overlaid by about ten feet of till. The cliff is about 300 feet long, and the beds dip S. 50° W. at an angle of 5° .

The following section is here shown :—

	ft. in.
Light blue or blue-gray clay shale or calcareous argillite, the bottom beds of which contain many specimens of <i>Chonetes Logani</i> , var. <i>Aurora</i> , while the top beds are of a slightly brownish colour.....	8 0
Thin and thick-bedded light blue-gray argillaceous limestone. These beds together with the base of the overlying shales are very fossiliferous, containing <i>Atrypa reticularis</i> , <i>Atrypa aspera</i> , <i>Strophodonta arcuata</i> , <i>Productella subaculeata</i> , <i>Spirifera fimbriata</i> , <i>Spirifera Richardsonii</i> , <i>Cyrtina Hamiltonensis</i> , <i>Paracyclas elliptica</i> , <i>Paracyclas antiqua</i> , <i>Raphistoma Tyrrellii</i> , <i>Bellerophon Pelops</i> , <i>Porcellia Manitobensis</i> , <i>Omphalocirrus Manitobensis</i> , <i>Hyolithes salatus</i> , <i>Proetus mundulus</i> , <i>Amplexus</i> sp., <i>Cyathophyllum vermiculare</i> , <i>Cyathophyllum petraoides</i> , <i>Alveolites</i> like <i>cryptodens</i> , <i>Actinoceras Hindii</i>	6 0
Thick and somewhat obscurely bedded light gray limestone, breaking on weathered surfaces into irregular fragments. It contains some of the same fossils as the beds above and appears to represent the beds in which <i>Atrypa reticularis</i> is most abundant. At	

Red Deer
River—Con.

its top a little brine is trickling out of the rock, and just east of the exposure is a small area in which springs of brine are flowing over the surface..... 8 0

Light gray thin and evenly bedded limestone, very compact, and resounding when struck with the hammer. It contains very few fossils. To the edge of the water..... 2 0

Three-quarters of a mile further up the river, on the south side, a low anticline striking N. 50° W. brings up six feet of the light blue-gray argillaceous limestone overlaid by a foot of light blue clay shale. A few fossils were found, the same as some of those in the above list.

Half a mile higher up the stream a low anticline brings seven feet of the light gray limestone to the surface, broken in several places by little faults. It also contains a number of fossils, the same as those already recorded from the Manitoban series on this river.

Upper Salt
Springs.

This last exposure is at a prominent bend in the river and a mile and a half above it a rounded hill rises on the north bank to a height of twenty feet, on the south side of which are several small brine springs where the Indians occasionally procure a small supply of salt by boiling down the water. The hill consists, to within four feet of the water at all events, of light gray limestone, the sloping face of which breaks off in irregular fragments. This locality was visited by Prof. Macoun* in 1881 and some fossils were collected from it, among which *Orthis striatula* (*O. Iowensis*) is especially noticeable as not having been obtained by the writer.

Fossils are, however, very abundant, and are generally very well weathered out by the action of the salt water. The following species were collected, and may be considered with the preceding list as a typical series for this northern portion of the Manitoban formation: *Cyathophyllum vermiculare*, var. *præcursor*, *C. Waskasense*, *C. petraoides*, *Alveolites* like *cryptodens*, *A. vallorum*? *Strophodonta arcuata*, *Cyr-tina Hamiltonensis*, *Atrypa reticularis*, *A. aspera*, *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Loxonema altivolvis*, *Proetus mundulus*.

Pelican
Rapids.

For the rest of the distance to Red Deer Lake the banks are generally composed of till or alluvium, but at the head of Pelican rapids a band of light gray limestone of the Manitoban series crosses the river. Where seen it was dipping southward at an angle of 12° and contained a few fossils, such as *Atrypa reticularis*, *Omphalocirrus Manitobensis*, *Proetus mundulus*, &c.

Red Deer
Lake.

Red Deer Lake lies in a very shallow basin and its shores are generally low and alluvial or composed of sand and boulders. In one place on

*Ann. Rep. Dept. of Interior, 1881, pt. 1, p. 75.



J. B. Tymell, Photo, Aug. 22, 1889.

CLIFF OF UPPER DEVONIAN LIMESTONE.

ROSE ISLAND, SWAN LAKE, MANITOBA. LAT. N. $52^{\circ} 36'$, LONG. W. $100^{\circ} 46'$.

the south shore, however, peeping out from under the boulders, and at an elevation of from two to three feet above the water, is an exposure, showing in all a foot of a light gray, white weathering, thin-bedded limestone, dipping east at an angle of 5° , and at a hundred yards farther east there is exposed for fifty paces along the shore a horizontally bedded, light gray, slightly magnesian limestone, often red from the presence of iron. In places it is evenly bedded, while in other places it is a breccia with very irregular pebbles.

In the entire absence of fossils it is impossible to determine the exact position of these beds, but it is reasonable to infer that they form part of the upper brecciated portion of the Manitoban series, which is well shown on several of the islands in Swan Lake.

Returning to Lake Winnipegosis, and ascending Shoal River Shoal River to the north end of Swan Lake, no rock is seen in place on or near the banks of the stream. Occasional areas are rendered wet and barren by flows of brine from salt springs, indicating the probable occurrence of the basal shales of the Manitoban series, under the covering of drift.

The shores of Swan Lake are also low, and the points are often Swan Lake, piled high with travelled boulders. But many of the islands consist of low bosses of limestone standing a few feet above the level of the water.

Rose Island lies towards the northern end of the lake, and consists Rose Island almost entirely of beautifully glaciated limestone which at the western end rises to a height of ten feet above the water, showing at the same place a dip of 8° to the south. The rock is the fine-grained compact limestone of the upper portion of the Manitoban series, and contains a few *Athyris vittata* and other characteristic fossils. In places it is brecciated, with a matrix of more or less soft argillite, but it is not improbable that the broken character is due to the occurrence of fissures or slight faults.

The three adjoining islands were also found to consist of the same limestone under precisely similar conditions.

Most of the remaining shores and islands of the lake are low, or Swan River delta. covered with boulders, but on the eastern side of the delta of Swan River there are two rocky prominences. The northern one, N. lat. $52^{\circ} 27' 45''$, long. $100^{\circ} 42'$ W. consists of a low exposure two feet above the water (August 31st, 1889), of a light gray stratified slightly argillaceous limestone belonging to the lower portion of the Manitoban series. On the shore were also lying many large slabs of somewhat similar limestone which had been shoved up by the ice from a thicker-bedded layer below the surface of the water. The rock con-

tains many large and well-preserved specimens of *Atrypa reticularis*, with some large *A. aspera*, besides *Paracyclas elliptica*, *Raphistoma Tyrrellii*, *Bellerophon Pelops*, *Gyroceras submamillatum* and *Proetus* sp. The beds here have a light dip of 1°–2° S. 60° E.

Rock cliff.

Two miles further south, the other rocky point consists of a little cliff eight feet in height. The rock is a thick-bedded gray limestone, breaking readily into small polygonal fragments, and is generally very similar to that composing Rose Island. It appears to be raised in a low anticline, striking south-east and north-west. At the north-eastern end of a small island off this point there is a low exposure of similar limestone, but in neither places were fossils characteristic of any particular horizon to be found.

A mile north-westward from the last point, and at the eastern end of a small lake, is a stony area in which are several little springs of brine, one of which is flowing about two gallons a minute and all the rest are together flowing about twice as much. The exact horizon in the Devonian from which the brine flows was undeterminable. For many years a local supply of salt has been obtained by the half-breeds from those brine springs, and their rusted iron evaporating-pans can be seen lying here and there on the ground.

Lowest trail crossing.

Two miles and a half west of the rocky cliff on the point, is the lowest trail-crossing of the Swan River, on the south side of which is a hill rising to a height of thirty feet above the river. On the north side of this hill is a cliff six feet high showing at the bottom three feet of a horizontally, thinly and evenly-bedded light reddish limestone which appears to be unfossiliferous, while above it is a band five feet thick of a cream-coloured limestone, often saccharine and porous, with many crystals of calcite. This upper band contains a few fossils, such as *Cyrtina Hamiltonensis*, *Raphistoma Tyrrellii*, &c., and the whole probably represents a horizon in the Manitoban series just below the base of the Point Wilkins beds.

No Palaeozoic rocks in place were found higher up the Swan River than in this hill at the crossing.

LAKE MANITOBA.

Low shores.

The shores south of Manitoba House were not closely examined, but they are generally low, with a ridge of sand and gravel running along at, or a little back from, the edge of the water. The water is shallow, and the gently declining lake bottom is studded with large gneissoid boulders, which are especially abundant off the more prominent points. No cliffs of the older rocks are apparent along the western shore of this portion of the lake.

North of Manitoba House the shore maintains much the same character, but boulders are stacked up somewhat more thickly on the points. On one of these points, a little north of the entrance to Ebb and Flow Lake, a boulder of Huronian conglomerate with pebbles of gneiss in a fine green matrix was lying in a pile of boulders of gneiss.

On both sides of this point extend ridges of rather angular pebbles of limestone.

On the east side of the lake, at Sifton Narrows, where the old location of the Canadian Pacific Railway can be plainly seen as a wide and well-cut-out line through the surrounding poplar forest, is a low exposure of porous Devonian limestone close to the edge of the water. Sifton Narrows.

Following the projected railway line eastward from the lake, a clearing is reached in the woods where a small quarry has been opened. Old quarry. The rock is a cream-coloured, harsh, semi-crystalline, porous, and very light dolomitic limestone, in which large open vesicles are rarely present. It effervesces feebly in weak hydrochloric acid, but dissolves readily in the acid when warmed, with a slight white residue. The bedding is thick and practically horizontal. 290 paces further eastward along the old line more extensive quarrying operations have been carried on. The rock is a magnesian limestone similar to the last, but here it is dipping westward at an angle of 19°, and is cut by two sets of more or less irregular jointage planes that dip at angles of 80° to the bedding. The directions of these two sets of planes are north and south, and N. 80° W. and S. 80° E. The rock weathers very rapidly, softening on exposure to the air.

It is a very poor medium for the preservation of fossils, but numerous fragments occur in this and the previous exposures, among which are large and small stems of Crinoids, *Cyathophyllum Anna*, *Cyathophyllum profundum*, *Pachypora cervicornis*, and *Atrypa reticularis*. Fossils.

In the last-mentioned quarry about ten feet in all of the limestone is exposed, while the other two exposures represent the same or slightly higher beds near the summit of the Winnipegosan formation.

A mile and a half north of the crossing of the old Canadian Pacific Railway, at the north end of Manitoba Island, is a cliff 200 paces in length and twelve feet high, composed of horizontal strata of hard, compact, brittle, thin-bedded limestone, very irregularly jointed and fractured. The general colour is cream, but in some places this runs into a bright buff or dull pink. A rather softer buff-coloured band runs along the face of the cliff five feet down from the top. Some of the more compact layers contain little masses and vugs of crystalline calcite, and occasional little pits are seen from which crystals of pyrite have weathered out. Manitoba Island.

Manitoba
Island—Con.

The rock breaks into very irregular flattened fragments. From the foot of the cliff a beach fifty feet wide of these flattened pebbles, which ring like a bell when struck with a hammer, with occasional boulders of gneiss, extends to the edge of the water. When the wind blows from the north and the waves roll on this shingle beach, carrying with them, both advancing and retiring, these resonant pebbles and dashing them against one another, a roaring noise is made which Indian superstition has attributed to the Manito beating a drum, or otherwise similarly disporting himself. Thus this part of the lake was called "Manito-bà," or the "Narrows of the Spirit," a name that was afterwards applied to the whole lake and then to the province in which the lake is situated.

The rock effervesces strongly in weak hydrochloric acid and dissolves quickly, leaving a flocculent pink residue of argillaceous material.

Fossils.

The beach at the foot of the cliff extends westward into a spit of coarse gravel, and in the pebbles that had evidently been derived from the cliff, a number of fossils were found, among which are the following: *Chonetes Manitobensis*, *Productella subaculeata*, *Atrypa reticularis*, *A. aspera*, *Nucula lirata*, *Nuculites* sp., *Paracyclas elliptica*, *Bellerophon* sp., *Orthoceras* sp., a tooth of a species of *Rhynchodus*, and a scale of a species of *Onychodus*.

On the east and west sides of the island low exposures of limestone are also seen, apparently horizontal, but it is generally a little softer and more yellowish-brown and argillaceous than at the cliff, and is probably a few feet lower.

Limestone on
west side of
strait.

On the opposite side of the strait, bearing south from the northwest end of Manitoba Island, is an outcrop 150 paces in length along the shore, of similar brittle salmon-coloured limestone. It is lying in well-defined beds of from two to six inches in thickness, and besides being broken by numerous small cracks, is cut by several series of jointage planes sloping at considerable angles from the vertical, and cracks and holes in the rock are filled with crystals and crystalline veins of calcite. The bedding appears on the whole to be about horizontal, though at the eastern end of the exposure the rocks rise in a light anticline striking N. 45° E., and dipping away on both sides at angles up to 2°. A little further west the beds all dip in towards a centre at the edge of the bushes. Nothing but obscure fragments of fossils could be found.

Base of
Manitoban
formation.

This limestone occupies a position at the base of the Manitoban formation, representing the southern continuation of the shales seen at South Manitou Island, and near the mouth of Bell River.

The exposed surface along the shore is smooth but lightly undulating, being modified by water erosion ; and at several places back from the shore, when it was stripped of its covering of clay, it was found to present the same character. The covering, however, generally consisted of broken fragments of the rock itself, probably shoved over it by the ice.

Proceeding northward along the east side of the lake, the next Point Richard exposure of Devonian rock is seen at a point on the west side of Point Richard, where a cliff rises abruptly out of moderately deep water to a height of ten feet, having been brought up by a low anticline striking N. 15° W. and S. 15° E. It is difficult to measure exactly the thickness of beds here exposed, as the bedding is heavy and indistinct, and it is only possible to examine it thoroughly from a boat in calm water, while during the day on which it was visited by the writer, a strong north wind was blowing, causing a heavy sea to beat against the face of the cliff. The section as measured, however, shows thirty feet of cream-coloured, hard, dolomitic limestone, like that seen further north at Monroe Point, full of small cavities left by the decay of numerous minute fossils, and weathering with a very irregular knobby surface. Five feet from the bottom of the section a few fossils were collected, consisting of small Crinoid stems, *Loxonema cingulatum*, and several other small gasteropods. The exposure represents a horizon about the summit of the Winnipegosan formation.

Off Point Richard lie two small islands consisting in the centre of boulders of gneiss and cream-coloured limestone, around which is a beach of gravel.

South of these islands is a deep bay with low shores fringed by a shelving beach of glistening shingle.

Reed Island was not examined, but it appeared to be low, without Reed Island. rock exposures, and surrounded by a beach of gravel or boulders.

The shore directly east of Point Richard is low, and broken only by prominent points surrounded by sloping walls of large gneissoid boulders, piled about six feet in height, between which are circling bays cut off from the low land behind by gravel beaches, or running back into deep marshes.

The shore all the way northward to Elm Point maintains precisely the same character.

Elm Point itself is, however, a spit of limestone gravel without Elm Point. boulders projecting southward into deep water, formed by the action of the shore current moving southward and carrying with it and assorting the pebbles derived from the wear of the shore to the north.

For a short distance north of Elm Point the shore is somewhat more regular than before, with fewer boulders collected on the points. In one place the land behind the beach is a few feet higher than the lake, but boulders are shoved up against it so thickly that no section can be seen. The land, however, in all probability here consists of till, and the action of the waves has carried away the finer material, while the shoving of the ice in spring has constantly tended to pile the boulders in a compact wall along the beach.

Steep Rock
Point.

Three miles and a half north of Elm Point Devonian limestone of the Manitoban series begins to make its appearance on the shore, and thence northward for two miles there is an almost continuous exposure of these rocks rising in a low anticline to a greatest height of twenty feet nine inches above the level of the water of July, 1888, while close to the foot of the highest part of the cliff the water is seventeen feet deep, giving the cliff a total height of more than thirty-seven feet.

Undermined
cliffs.

The rock is white or light gray limestone, moderately thin-bedded and breaking very irregularly into angular fragments. About twenty-five feet in all are exposed and of these the lower beds are the most friable and easily worn away by the water, forming an irregular overhanging cliff, through narrow parts of which the waves have in several instances cut wide apertures, while in other places, planes of jointage have carried back the erosive agents to wear out narrow bays and caverns, the floors of which are formed of rounded limestone pebbles broken from the cliff itself.

The strata, which are just above the basal argillites or argillaceous limestones of the Manitoban formation, are not at all rich in fossils, but nevertheless the following species have been collected, viz.:—*Favosites Gothlandica*, Crinoid stems, *Monotrypa* sp., *Atrypa reticularis*, *Atrypa aspera*, *Pentamerus comis*, *Gyroceras submamillatum*, *Bellerophon Pelops*, *Euomphalus Manitobensis* and remains of fishes.

Glacial striæ.

The surface of the rock in a number of places shows well-marked glacial grooves and striæ bearing S. 13° E., and in one place, at the north-west extremity of the point, the striæ are bearing S. 2° W., while at another place on the north-east side of the point they are bearing S. 1°—8° E. At this latter place they are on a sloping beach close to the edge of the water.

The surface of the limestone is generally covered with two or more feet of clay, filled with angular fragments of the rock itself derived from close at hand, and this is often overlaid by rounded limestone gravel, while along the shore on the side of the point, boulders of gneiss are thickly scattered.

From Steep Rock Point to the head of Fairford River the shore is low and consists of a gravel ridge, on the edge of a marsh that stretches back into the interior.

At the discharge of Lake Manitoba into the Fairford River, a band of white limestone, probably of Silurian age, crops out on the south bank close to the edge of the water, and extends northward beneath the bed of the stream. It is a white, hard, thin-bedded, and semi-crystalline limestone, and eighteen inches in all is exposed. No fossils could be found. Its surface is polished and striated, the striae running S. 13° E. Rock at head of Fairford River. Glacial striae.

A mile to the east of this is a ridge six feet in height running S. 13° E., and apparently composed of the same rock, while in the vicinity of the Fairford Mission Church, and for a mile or more to the east of it, similar rock immediately underlies the surface, and occasionally rises into view in little bare knolls.

A mile and a half a little north of east from the Mission and just south of a road to Lake St. Martin, the rock comes to the surface and in it is a hole, five feet in diameter, running straight down for fourteen feet, and expanding somewhat at the bottom. I was told that the Indians of the vicinity ascribe the formation of this hole to a great snake that lived in former times. Even now they refuse to go down into it. It gives a section from top to bottom of hard compact white limestone, in places rather thin-bedded. Vertical cave.

The cave has been formed by water charged with carbonic acid trickling through fissures in the limestone and dissolving out its more soluble portions. When examined in July, 1888, the bottom was covered with ice.

No fossils were found anywhere throughout this band of limestone, Silurian, but it would seem evident that it is a continuation of the Silurian magnesian limestone that occupies the east side of Lake Winnipegosis, north of Birch Island.

North-west of the head of Fairford River the shore of the lake is generally low, and it is not till the vicinity of Davis Point is reached that the Silurian again makes its appearance. At the southern end of this low exposure, a thin and even-bedded dolomitic limestone crops out of the bank near the water's edge, and many slabs of the same rock are scattered over the shore. No fossils were found in it, but it is doubtless the same band as is exposed at Fairford.

At the north end of the exposure, and apparently overlying the last-mentioned rock, is a layer of very thick-bedded limestone, also slightly dolomitic. It is yellow, hard and tough, but not compact like the

last, being largely composed of the debris of Stromatoporoids and corals. It weathers white, with a very rough surface.

The following fossils were collected from this latter bed : *Clathrodictyon ostiolatum*, *Clathrodictyon vesiculosum*, *Pycnostylus Guelphensis*, *Zaphrentis*, sp., and *Favosites Gothlandica*.

The north shore of Portage Bay is low, without rock exposures, with long points of boulders running out in the direction of general glacial striation. The islands off the shore are also chiefly composed of gneissoid boulders, and from the highest points there are low ridges extending S. 8° E. in the same direction as the points.

Paonan Point. The shores of Paonan Point, as far as they were examined, were also found to present in most places a boulder wall to the lake, while in the interior the land was low and marshy. Cherry Island, off the southern extremity of this point, is also surrounded by boulders on its southern side, while its northern side is a beach of gravel and sand.

**North shore
of lake.**

West of the portage at the north end of Paonan peninsula, to the mouth of Waterhen River, no rock is seen anywhere on the north side of the lake, but the shore is everywhere low and the points and islands are surrounded by boulders, often piled up to a height of six to eight feet. Off the points, boulder reefs frequently extend into the lake for a considerable distance, while the deep bays lying between the points run back to extensive marshes. The boulders are chiefly of gneiss, mica schists and other Archæan rocks, while the pebbles on other parts of the shore are mostly of white limestone. Some of these hold impressions of salt crystals, and doubtless have been transported by the glacier from the Silurian limestone to the north.

**Big Sandy
Point.**

Returning to Sifton Narrows, and thence proceeding northward up the west side of Lake Manitoba, the country is found to be very similar to that on the east side of the lake. The shore, however, is not so thickly strewn with boulders, which are generally confined to the more prominent points and to little rocky islands, while the beach in most places is composed of a ridge of finer or coarser limestone gravel extending along the face of a marsh which stretches back to a poplar forest. No rock in place is seen till Big Sandy Point is reached, one of the best known harbours on the lake. It is a spit of small pebbles of limestone and gneiss rising six feet above the water, which is six to eight feet deep close to the shore.

North of the harbour is a rocky hill, the face of which forms a cliff ten feet high overlooking the lake. It is composed of a harsh semi-crystalline very light brown magnesian limestone, which weathers to a somewhat darker shade of brown. It is rather thick-bedded and approximately horizontal, though the beds appear to have an undulat-

ing dip. Fossils were poorly preserved, but the following were recognized :—*Pachypora cervicornis*, Crinoidal columns, *Atrypa reticularis*, *A. aspera*, and *Pentamerus comis*.

The shore onwards past Crane River narrows is piled high with Munroe boulders, and the next Devonian exposure seen was at Monroe Point, on the west side of the mouth of Crane River. There are here three minor points, at which are little cliffs, showing respectively nine, nine, and six feet of a tough white compact or vesicular and entirely uncryalline dolomitic limestone. In some of the compact bands, where no vesicles are present, a smooth, newly fractured or polished surface of the rock shows a kind of oolitic structure, the round or irregularly shaped oolitic grains being more opaque than the surrounding matrix. The bedding is heavy and horizontal, but at the south-easterly point there are several series of jointage planes, along which there would seem to be slight faults, with throws of a foot or two.

A large number of fossils were collected here, of which the following were broken out of the face of the cliff itself :—*Pachypora cervicornis*, *Favosites Gothlandica*, Crinoidal columns, *Cystodictya Hamiltonensis*, *Polypora Manitobensis*, *Atrypa reticularis*, *A. aspera*, *Strophalosia productoides*, *Spirifera fimbriata*, *Conocardium Ohioense*, *Euomphalus annulatus*, *Loxonema priscum*, *Loxonema cingulatum*, *Bellerophon Pelops*, *Orthoceras* sp., *Bronteus Manitobensis*.

The following species were collected from the rock debris at the bottom of the cliff, and apparently have been derived from it :—*Sphaerospongia tessellata*, *Pentamerus comis*, *Terebratula Sullivanti*, *Dentalium antiquum* ?, *Naticopsis Manitobensis*, with several other small species of gasteropods.

The surface of the rock on the top of the cliff was in one place found to be smooth and glaciated, but the striæ had been entirely weathered out.

Three miles and a half north of Monroe Point, Pentamerus Point projects into the lake and is strewn with large irregular masses of dolomite. Off the point, a foot below the surface of the water, the bottom is found to be composed of bed rock, and the masses lying on the point have been broken from this ledge by the action of the frost and shoved up on the shore by the ice. The rock is a hard, white, vesicular dolomite, similar to that seen outcropping at Monroe Point, and, like it, containing a large number of fossils, of which the following are the most typical :—*Sphaerospongia tessellata*, *Actinostroma fenes-tratum*, *Calumnaria disjuncta*, *Favosites Gothlandica*, *Pachypora cer-vicornis*, a Polyzoan, Crinoidal columns, *Atrypa reticularis*, *A. reticu-* Point.

laris, var. *aspera*, *Spirifera fimbriata*, *Pentamerus comis*, *Rhynchonella pugnus*, *Stringocephalus Burtini*, *Terebratula Sullivanti*, *Actinopteria Boydii*, *Myalina inflata*, *Spathella subelliptica*, *Glossites Manitobensis*, *Dentalium antiquum*, *Pleurotomaria infranodosa*, *Pleurotomaria* (sp. reversed), *Porcellia Manitobensis*, *Eunema clathratulum*, *Astralites fimbriatus*, *Euomphalus annulatus*, *Omphalocirrus Manitobensis*, *Straparollina obtusa*, *Platyostoma tumidum*, *Naticopsis Manitobensis*, *Loxonema priscum*, *Pleurotomaria Spenceri*, *Gyroceras filitextum*, *Orthoceras Tyrrellii*, and *Bronteus Manitobensis*.

Horizon.

These two localities are quite typical of the Winnipegosan formation.

Five miles a little west of north from Pentamerus Point, a prominent point stretches out into the lake to the west of the harbour of Little Sandy Point, and is underlaid by a rather thin-bedded bluish-gray limestone, rising with a gentle slope out of the water. Its surface is well glaciated, showing grooves bearing S. 12° W., crossed by fine striæ bearing S. 8° E. The rock holds a few fossils, the same as those just to be recorded from Onion Point.

A slight exposure of similar limestone forms a little cliff at Flat Onion Point, but the main exposure is at Onion Point, a mile and a half still further west. Here a vertical cliff, eight feet high, faces the lake, and extends 150 yards along the shore. It is composed of white or light gray limestone, very evenly bedded, and the beds appear on the face of the cliff to be from two to three feet in thickness, but they readily break into thinner layers, and have also an irregular cross-fracture which would make it difficult to quarry pieces of any considerable or regular size.

Anticline.

The rock is brought up by a low anticline striking N.W., and towards the north-east it dips at an angle of 2° to the edge of, and beneath the water, while to the south-west it breaks off abruptly above a tail heap of large boulders. The total thickness of rock seen is nine feet six inches.

Fossils

Fossils were very plentiful, but, unlike those at Monroe and Pentamerus points, they belong to comparatively few species. *Atrypa reticularis*, *A. reticularis*, var. *aspera* and small Crinoidal columns are particularly abundant, while *Paracyclas elliptica*, *Euomphalus Manitobensis* and *Raphistoma Tyrrellii*, are found in considerable numbers. With them the following species also occur:—*Pachypora cervicornis*, *Cyathophyllum petraoides*, *Cyrtina Hamiltonensis*, *Productella subaculeata*, *Kefersteinia subovata?*, *Bellerophon Pelops*, *Loxonema altivolvis*, *Euomphalus circularis*, var. *subtrigonalis*, *Orthoceras Hindii*, and *Hyolithes alatus*.

This locality is typical of a zone near the base of the Manitoban formation.

SYSTEMATIC GEOLOGY.

TABLE OF FORMATIONS.

	Feet.
RECENT.	
Present lake beaches. Delta deposits in Dauplin, Swan and Red Deer Lakes, &c.	
POST TERTIARY.	
<i>Champlain.</i>	
Terraces in the valleys of Shell and Assiniboine rivers and their tributaries. Beaches and deltas of Lake Agassiz on the slope of the Manitoba escarpment, at least as far northward as Red Deer River.	
<i>Glacial.</i>	
Till on the general surface. Moraines on and in front of the Riding, Duck and Porcupine mountains; north of Lake Winnipegosis, &c. Drumlins in the lakes, and in the Assiniboine valley. Kames in the Valley river valley, &c.	
<i>Inter or Preglacial.</i>	
Clays and sands on Rolling River and at Churchbridge.	
CRETACEOUS.	
<i>Pierre.</i>	
Odanah Series.	
Light gray hard fissile shales very poor in fossils, occurring on the upper portion of Riding Mountain and southward to the International Boundary line.	400
Millwood Series.	
Dark gray soft shale.	664
<i>Niobrara.</i>	
Light gray mottled calcareous clay shale with bands of chalky limestone, everywhere containing a large number of foraminifera.*	130-540
<i>Benton.</i>	
Dark gray very soft non-calcareous clay shale, poor in fossils, and weathering into gentle slopes.	160
<i>Dakota.</i>	
A rather soft white or light gray sandstone often calcareous.	13-200
DEVONIAN.	
<i>Upper Devonian or Manitoban.</i>	
Light gray hard brittle limestone containing <i>Athyris vittata</i> , &c., underlaid by red argillites, outcropping at Rose Island and vicinity in Swan Lake, and at Point Wilkins.	100
Light gray hard limestone seen at Onion Point, Snake Island, Beardy Island, &c.	40
Red and gray shale seen near the mouth of Bell River, south of Weston Point, &c.	70

Middle Devonian or Winnipegosan.

Feet.
100
100
100

Lower Devonian.

These beds have not been clearly defined, but they appear to be composed of red and other shales.

SILURIAN.*Niagara.*

Compact, thin bedded dolomites, found chiefly on the west side of Lake Winnipegos.

Compact and porous dolomites containing a considerable number of fossils, seen on Cross Lake and vicinity.

Hard, tough, light yellowish dolomitic limestone, seen on the Saskatchewan River at Grand rapids.

Soft white or light yellow chalky or argillaceous limestone, with a number of fossils. Near the bottom is a hard band containing large numbers of *Pentamerus decussatus*.

200

SILURIAN.**Area.**

The Silurian occupies the whole of the north-eastern portion of the area described in the present report, where it is represented by a series, a few hundred feet in thickness, of light gray limestones and dolomites.

Lower Niagara limestone.

The lower portion of the system is best shown in the gorge at the Grand Rapids, near the mouth of the Saskatchewan River, where it outcrops in a horizontal attitude a few miles south of an exposure of Trenton limestone on the west side of Lake Winnipeg.

The following descending section is here shown :—

	ft.
1. White thin-bedded limestone.....	15
2. Covered	6
3. Soft yellow limestone.....	8
4. Gap in section.....	10?
5. Hard yellow magnesian limestone.....	4
6. Moderately thin-bedded white limestone.....	8
7. Hard compact buff limestone.....	1
8. Brecciated limestone.....	2
	<hr/>
	54
	<hr/>

The three lower bands are, as far as is at present known, quite unfossiliferous, while No. 5 contains a great number of a beautifully preserved *Pentamerus*, recently described by Mr. Whiteaves as *P. decussatus*. With it are found *Favosites Niagarensis*, *Alveolites* sp., *Lyellia* sp., *Halysites catenulatus*, *Orthis* sp., and *Euomphalus* sp.

Above No. 5 is a gap in the section where the beds have been worn away, being in all probability too soft to resist erosion to the same extent as the surrounding beds.

In band No. 3 fossils were not plentiful, but *Strophomena acanthoptera* and *Leperditia Hisingeri*, var. *fabulina* were collected. This band is generally porous and contains a large number of impressions of salt crystals. In places the bedding is moderately even and horizontal, but generally it is hardly discernible, and the rock breaks into very irregular lumpy pieces. Lying on the bank, and having been apparently derived from this band, are some nodules of marcasite, and red masses of ironstone.

No. 1 is a thin-bedded, white, horizontal, chalky limestone, in places argillaceous, very light, and breaking regularly when struck with the hammer. It has a more or less granular structure, and in places was strongly ripple-marked. A thin band a few feet below the top, contains a considerable number of fossils, among which are the following: *Favosites Niagarensis*, *Leptocelia* sp., *Rhynchonella* sp., *Pterinea aviculoides* ?, *Pleurotomaria occidens*, *Orthoceras* sp., *Gomphoceras parvulum*, *Leperditia Hisingeri*, var. *egena*, *Leperditia cæca*, and *Isochilina grandis*, var. *latimarginata*.

This series is sharply delimited above, and probably also below, though its exact contact with lower beds has not been observed. It appears to occupy a position at the base of the Silurian (as distinguished from the Cambro-Silurian) system and probably represents the lower part of the Niagara of Wisconsin, &c.

Overlying the lower Niagara limestones is a considerable thickness, Upper possibly a few hundred feet, of dolomites and dolomitic limestones of Niagara limestone. Upper Niagara age.

The base of this series is well shown in the gorge of the Grand Rapids, Grand Rapids where it consists of ten feet of a hard, tough, light-yellowish dolomitic limestone, rather indistinctly bedded, but conformable to the underlying series. It is generally clearly fragmental, and in its lower portion contains a large number of salt crystals. Fossils are here moderately plentiful, but difficult to break out. Crinoid stems are very abundant, and with them are *Favosites Gothlandica*, *Zaphrentis* sp., and *Strophomena acanthoptera*.

This crinoid bed grades up into, and is overlaid by, from twenty to thirty feet of hard, brittle, yellow dolomite, generally thinly and evenly bedded. The only fossil here appears to be a large Stromatoporoid.

This compact band is overlaid by a porous yellow dolomite in moderately thin but uneven beds, and contains many impressions of salt crystals.

Cedar and
Winnipegosis
Lakes.

From Grand Rapids, where the above section was obtained, beds of this series have been traced westward through Cross Lake to the extreme west end of Cedar Lake, and down the east shore of Lake Winnipegosis from its north-east angle to latitude $52^{\circ} 32'$, as well as on the Fairford River and at several points around Lake St. Martin. Throughout this distance all the exposures are low and practically horizontal, and though there is considerable local variation in the character of the rock, it is doubtful whether the variations are sufficiently persistent to enable the geologist to determine with any degree of accuracy the total thickness of the terrane. In many places the beds are hard and almost slate-like, but these merge both vertically and horizontally into others that are much more porous and often contain many impressions of salt crystals. At the north-east angle of Lake Winnipegosis one bed is thick and almost porcellanous in texture, and close by is another heavy bed containing many large and small nodules of gray chert. In the immediate vicinity is a thin-bedded slaty dolomite very much broken by minute fissures, and having its surface often thickly strewn with fossil ostracods. Farther north, at Cross Lake Rapids, similar ostracodous dolomites are associated with more porous and highly fossiliferous beds, corresponding closely with the Niagara limestone of Wisconsin.

Niagara
fossils.

The following is a rough provisional list of the fossils found in this formation:—

- Stromatopora* sp.
- Calapæcia* sp.
- Zaphrentis Racinensis*? Whitfield.
- Cyathaxonia Wisconsinensis*? Whitfield.
- Omphyma* sp.
- Favosites Gothlandica*, Lamarck.
- Favosites Niagarensis*, Hall.
- Alveolites Niagarensis*, Rominger.
- Halysites catenulatus*, L.
- Lyellia papillata*? Rominger.
- Orthis* sp.
- Strophomena acanthoptera*, Whiteaves. N. sp.*
- Rhynchonella* sp.
- Rhynchonella altiplicata*? Hall.
- Atrypa reticularis*, L., (young).
- Leptocælia* sp.
- Meristella* sp.
- Pentamerus decussatus*, Whiteaves. N. sp.
- Trematospira formosa*, Hall.
- Pterinea aviculoidea*? Hall.

* N. sp. is inserted in these lists after species described in the reports cited on pages 19 and 20 from collections made in the course of the present exploration.

- Murchisonia* sp.
Pleurotomaria occidens, Hall.
Pleurotomaria Hoyi? Hall.
Pleurotomaria sp.
Polytropis sp.
Euomphalus sp. (very small).
Orthoceras sp.
Orthoceras sp.
Gomphoceras parvulum, Whiteaves. N. sp.
Gyroceras sp.
Dalmanites sp.
Illaenus sp.
Acidaspis perarmata, Whiteaves. N. sp.
Isochilina grandis, var. *latimarginata*, Jones. N. var.
Leperditia Hisingeri, var. *fabulina*, Jones. N. var.
 " " " *egena*, Jones. N. var.
 " " " *gibbera*, Jones. N. var.
 " *cæca*, Jones. N. sp.
 " *phaseolus*, Hisinger.
 " *Whiteavesii*, Jones. N. sp.
 " *marginata*, Schmidt.

In the vicinity of Lake St. Martin thin-bedded dolomites of this Southern formation rest directly on and against rounded bosses of red micaceous granite, and green soda-rich syenite porphyry, which have formed elevated portions of the Archæan floor on which the Palæozoic rocks of Manitoba were deposited. Elsewhere they would appear to rest on undisturbed limestones and shales of Cambro-Silurian age.

A short distance west of these isolated bosses of Archæan rocks Gypsum, an irregular hilly tract rises above the gently sloping wooded plain. The hills are found for the most part to be composed entirely of massive or crystalline gypsum, while a few consist of light bluish-white anhydrite.

On the eastern shore of Lake Manitoba, a short distance west of this gypsum outcrop, the thin-bedded Upper Niagara dolomites are overlain by a few feet of a thick-bedded massive stromatoporoid magnesian limestone in which the only fossils found were a few corals, but among them *Pycnostylus Guelphensis* could be easily recognized. This limestone forms the upper beds of the Niagara of this region, but it has not been deemed advisable to separate the horizon as Guelph on the evidence of a fossil whose range is so little known, especially as the Leperditia beds below it show so many points of similarity to the Lower Helderberg of Wisconsin.

South of the region of the lakes the Silurian has not yet been outlined, but some fragments of rock collected from the top beds at Stonewall look as if they might belong to this system, and the high ridge between Lakes Manitoba and Winnipeg is not improbably capped by beds of the same age.

DEVONIAN.

Position.

Lower Devonian.

Overlying the Niagara dolomites in the region of Lakes Winnipegosis and Manitoba there is a considerable thickness, probably a hundred feet or more, of strata, of which no natural exposures have yet been recognized. That these strata are softer than the overlying and underlying beds, is testified to both by the absence of any cliffs of hard rock, and by the presence of an extended depression along the strike of the beds, now largely occupied by the above-mentioned lakes. A bed of red clay or shale, just above this gap, is seen on Pemmican Island, &c., and it is not improbable, considering the argillaceous character of many of the overlying limestones, that the whole of the concealed series is composed of argillaceous shales or soft limestones. The absence of sand from the till of that region makes it unlikely that much sandstone is included in the series.

These shales are placed at the local base of the Devonian system, since the above-mentioned red bed lies conformably below Devonian dolomites, and there is little or no evidence at hand to prove the presence or absence of an unconformity at the top of the Silurian. These shales may, therefore, possibly represent the Corniferous in Manitoba, and the Palaeozoic strata passed through in the Morden well probably represent the more southern continuation of this formation.

Winnipegosan formation.

Hard dolomites.

The next rock in ascending order is a series of light brown or gray, harsh, porous, and very irregularly weathering, dolomitic limestones, having a probable thickness of a hundred feet or more. This zone or terrane contains a number of typical Devonian fossils, among which the following are some of the most characteristic, viz.: *Atrypa reticularis*, *Pentamerus comis*, *Productella subaculeata*, *Paracyclas elliptica*, *Paracyclas antiqua*, *Bellerophon Pelops*, *Straparollina obtusa*, &c. Nearly all these fossils are also characteristic of the immediately overlying zone.

Stringocephalus zone.

The harsh dolomites are overlaid by a somewhat similar thickness of very thick-bedded white tough dolomites, often containing more porous bands, in which are many well-preserved casts of salt crystals. These compact dolomites have yielded a rich harvest of fossils, among which are many forms, such as *Stringocephalus Burtini*, *Pentamerus*

comis, &c., typical of the Middle Devonian of Europe. The harsh, and the compact dolomites are therefore regarded as the lower and upper portions of the Winnipegosan formation or Middle Devonian. They are best exposed on the islands and shores of Dawson Bay, near the north-west extremity of Lake Winnipegos, and isolated outcrops are seen on the shores as far south as "Sifton's Narrows," on Lake Manitoba. South of this point no natural exposures of Devonian rocks have yet been recognized in the province of Manitoba.

Above the Winnipegosan dolomites the base of the Manitoban formation or Upper Devonian consists of red and gray calcareous shales, from forty to seventy feet in thickness, containing comparatively few fossils. These shales are, however, almost everywhere marked along their eastern outcrop by brine springs that pour a copious flow of salt water over the surface of the underlying dolomites.

Above the shales is a comparatively thin band of argillaceous and highly fossiliferous light gray limestone, in which *Atrypa reticularis* and *Paracyclas elliptica* are especially abundant.

The highest Palæozoic rocks seen in Manitoba, but possibly still low down in the Upper Devonian, outcrop on some islands in Swan Lake, and in the high promontory of Point Wilkins, on the west side of Dawson Bay. They consist of from sixty to eighty feet of light gray compact brittle limestone not very rich in fossils, but those that are present, viz.: *Atrypa reticularis*, *Cyrtina Hamiltonensis*, *Athyris vittata*, *Paracyclas elliptica*, *Bellerophon Pelops*, &c., are typically Devonian.

The following is a list of the fossils from the Devonian rocks of Manitoba and vicinity, all of which, except *Orthis striatula*, were collected on the recent explorations under the charge of the writer. The letters M. and U. indicate that they were found in either the Middle or Upper Devonian, respectively.

PROTOZOA.

<i>Sphaerospongia tessellata</i> , Phillips.	M.
<i>Astræospongia Hamiltonensis</i> , Meek & Worthen.	M.

CŒLENTERATA.

<i>Cyathophyllum vermiculare</i> , var. <i>præcursor</i> , Frech.	U.
" <i>dianthus</i> , Goldfuss.	U.
" <i>Waskasense</i> , Whiteaves. N. sp.	U.
" <i>petraoides</i> " N. sp.	U.
" <i>Anna</i> , Whitfield.	M.
" <i>profundum</i> , Hall.	M.
" <i>profundum</i> , Hall, var.	U.
" <i>Athabascense</i> , var.	U.

<i>Columnaria disjuncta</i> , Whiteaves. N. sp.	M.
<i>Amplexus</i> sp.	M.
<i>Actinocystis variabilis</i> , Whiteaves. N. sp.	M.
<i>Favosites Gothlandica</i> , Lamarck.	M.
<i>Pachypora cervicornis</i> , DeBlainville.	M.
<i>Pachypora</i> or <i>Alveolites</i> .	U.
<i>Alveolites vallorum</i> , Meek.	M. U.
<i>Clathrodictyon</i> (like <i>C. laxum</i> , Nicholson.)	U.
<i>Stromatopora</i> sp. (cfr. <i>L. Bücheliensis</i> , Bargatzky.)	M.
“ sp. (cfr. <i>L. Hüpschii</i> , Bargatzky.)	M. U.
<i>Actinostroma expansum</i> , Hall & Whitfield	M.
“ <i>Tyrrellii</i> , Nicholson. N. sp.	M.
“ <i>fenestratum</i> , Nicholson.	M.

ECHINODERMATA.

<i>Ctenocrinus</i> sp.	M.
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VERMES.

<i>Spirorbis omphalodes</i> , Goldfuss.	M.
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POLYZOA.

<i>Leptotrypa quadrangularis</i> , Nicholson.	U.
<i>Pinacotrypa marginalis</i> , Whiteaves. N. sp.	M.
<i>Cystodictya Hamiltonensis</i> , Uhrlrich.	M.
<i>Fenestella vera</i> , Uhrlrich.	M.
“ <i>dispanda</i> ? Hall.	M.
<i>Polypora Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Monotrypa</i> sp.	U.

BRACHIOPODA.

<i>Discina</i> sp.	M.
<i>Chonetes Logani</i> , var. <i>Aurora</i> , Hall.	U.
“ <i>Manitobensis</i> , Whiteaves. N. sp.	U.
<i>Strophalosia productoides</i> , var. <i>membranacea</i> .	M.
<i>Productella subaculeata</i> , Murchison.	M. U.
<i>Orthis striatula</i> , Schlotheim.	U.
“ <i>Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Orthothetes Chemungensis</i> , Conrad.	M.
<i>Strophodonta arcuata</i> , Hall.	U.
“ <i>intertrialis</i> , Phillips.	M.
<i>Spirifera fimbriata</i> , S. A. Miller.	M. U.
“ <i>Richardsonii</i> , Meek.	M. U.
<i>Cyrtina Hamiltonensis</i> , Hall.	U.
<i>Athyris vittata</i> , Hall.	U.
<i>Atrypa reticularis</i> , L.	M. U.
“ “ var. <i>aspera</i> , Schlotheim.	M. U.

<i>Rhynchonella pugnus</i> , Martin.	M.
<i>Pentamerus comis</i> , Owen.	M. and base of U.
<i>Stringocephalus Burtini</i> , Defrance.	M.
<i>Terebratula Sullivanti</i> , Hall.	M.

LAMELLIBRANCHIATA.

<i>Pterinea lobata</i> , Whiteaves. N. sp.	M.
<i>Actinopteria Boydii</i> , Conrad.	M.
<i>Gosseletia</i> sp.	M.
<i>Mytilarca inflata</i> , Whiteaves. N. sp.	M.
<i>Myalina trigonalis</i> , " N. sp.	M.
<i>Modiomorpha attenuata</i> , Whiteaves. N. sp.	M.
" <i>compressa</i> , " N. sp.	M.
" <i>tumida</i> , " N. sp.	U.
" <i>parvula</i> , " N. sp.	M.
<i>Spathella subelliptica</i> , " N. sp.	M. U.
<i>Goniophora perangulata</i> , Hall.	M.
<i>Macrodon pygmæus</i> , Whiteaves. N. sp.	M.
<i>Nucula lirata</i> , Conrad.	U.
" <i>Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Nuculites</i> sp.	U.
<i>Kefersteinia subovata</i> , Whiteaves. N. sp.	M. U.
<i>Mecynodon Eifeliensis</i> ?, Frech.	M.
<i>Anodontopis affinis</i> , Whiteaves. N. sp.	M.
<i>Paracyclas antiqua</i> , Goldfuss.	M.
" <i>elliptica</i> , Hall.	U.
" " var. <i>occidentalis</i> , Billings.	U.
" sp.	M.
<i>Conocardium Ohioense</i> , Meek.	M.
<i>Cardiopsis tenuicostata</i> , Whiteaves. N. sp.	M.
<i>Cypriocardella bellistriata</i> , Conrad.	M. U.
" <i>producta</i> , Whiteaves. N. sp.	M.
<i>Cypriocardinia planulata</i> , Conrad.	M.
<i>Glossites Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Orthonota corrugata</i> , Whiteaves. N. sp.	M.

GASTEROPODA.

<i>Dentalium antiquum</i> ? Goldfuss.	M.
<i>Palaeacmaea cingulata</i> , Whiteaves. N. sp.	M.
<i>Pleurotomaria goniostoma</i> , Whiteaves. N. sp.	M.
" <i>infranodosa</i> , " N. sp.	M.
<i>Pleurotomaria Spenceri</i> , " N. sp.	M.
<i>Raphistoma Tyrrellii</i> , Whiteaves. N. sp.	M. U.

<i>Murchisonia turbinata</i> , Schlotheim.	M.
" <i>Dowlingii</i> , Whiteaves. N. sp.	M.
<i>Bellerophon Pelops</i> , Hall.	U.
<i>Porcellia Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Eunema speciosum</i> , Whiteaves. N. sp.	M.
" <i>brevispira</i> , " N. sp.	M.
" <i>subspinosum</i> , " N. sp.	M.
" <i>clathratulum</i> , " N. sp.	M.
<i>Astralites fimbriatus</i> , " N. sp.	M.
<i>Euomphalus annulatus</i> , Phillips.	M.
" <i>subtrigonalis</i> , Whiteaves. N. sp.	U.
<i>Omphalocirrus Manitobensis</i> , " N. sp.	U.
<i>Straparollina obtusa</i> , " N. sp.	M.
<i>Pseudophorus tectiformis</i> , " N. sp.	M.
<i>Platyceras parvulum</i> , " N. sp.	M.
<i>Platyostoma tumidum</i> , " N. sp.	M.
<i>Naticopsis Manitobensis</i> , " N. sp.	M.
" <i>inornata</i> , " N. sp.	M.
<i>Loxonema altivolvis</i> , " N. sp.	U.
" <i>priscum</i> , Munster.	M.
" <i>cingulatum</i> , Whiteaves. N. sp.	M.
" <i>gracillimum</i> , " N. sp.	M.
<i>Macrochilina subcostata</i> , Schlotheim.	M.
" <i>pulchella</i> , Whiteaves. N. sp.	M.

PTEROPODA.

<i>Hyolithes alatus</i> , Whiteaves. N. sp.	M. U.
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CEPHALOPODA.

<i>Orthoceras Hindii</i> , Whiteaves. N. sp.	U.
" <i>Tyrrellii</i> , " N. sp.	M.
<i>Gomphoceras Manitobense</i> , Whiteaves. N. sp.	U.
<i>Cyrtoceras occidentale</i> , " N. sp.	M.
<i>Homaloceras planatum</i> , " N. sp.	M.
<i>Tetragonoceras gracile</i> , " N. sp.	M.
<i>Gyroceras Canadense</i> , " N. sp.	M.
" <i>filicinctum</i> , " N. sp.	M.
" <i>submamillatum</i> , " N. sp.	U.

CRUSTACEA.

<i>Isochilina Dawsoni</i> , Jones. N. sp.	M.
<i>Elpe Tyrrellii</i> , " N. sp.	M.

<i>Leperditia exigua</i> , Jones.	M.
<i>Bronteus Manitobensis</i> , Whiteaves. N. sp.	M.
<i>Lichas</i> sp.	M.
<i>Cyphaspis bellula</i> , Whiteaves. N. sp.	M.
<i>Proetus mundulus</i> , " N. sp.	M. & U.

FISHES.

<i>Ptyctodus calceolus</i> , M. & W.	U.
<i>Rhynchodus</i> sp.	U.
<i>Dinicthys Canadensis</i> , Whiteaves. N. sp.	U.
<i>Aspidichthys notabilis</i> , " N. sp.	U.
<i>Onychodus</i> sp.	U.

South of "Sifton Narrows" on Lake Manitoba, no Devonian rocks are known to outcrop within the Province of Manitoba. Northward and north-westward of Lake Winnipegosis the characters of the Palaeozoic rocks, other than those on Cedar Lake, have not yet been determined throughout a distance of almost five hundred miles, or till the Clearwater and Athabasca Rivers are reached. Here Devonian rocks, very similar in character to the Upper Devonian of Manitoba, have again been recognized, and traced northward along the Athabasca and Mackenzie rivers to within the Arctic Circle.

CRETACEOUS.

Dakota.

This formation, resting unconformably on the limestones of the Sandstone Devonian, is composed of white or reddish sandstones, either cemented by a calcareous matrix or often quite incoherent, being then an even-grained white quartzose sand. It grades up into a light green and rather hard sandstone, commonly interstratified with thin bands of shale.

Very few fossils have been found in this sandstone, and those that have been found are confined to the greenish upper beds. They consist chiefly of carbonized fragments of wood and coniferous leaves, but the following animal remains have also been collected, viz. :—

- Lingula subspatulata*, Hall and Meek.
- Ostrea congesta*, Conrad.
- Modiola tenuisculpta*, Whiteaves. N. sp.
- Cycloid scales of fishes.

The terrane can be seen in several exposures along the foot of the northern portions of the Manitoba escarpment, as on the banks of Red Deer, Armitt, Kematch and Swan rivers, and on Kettle Hill, south of

Swan Lake. Also at Pemmican Island, in Lake Winnipegosis, there are evidences of the presence of this or the overlying terrane.

Thickness.

The exposures were altogether too small and infrequent to allow of any exact determination of its total thickness to be made, but on account of the irregularity of the Palaeozoic floor on which it was laid down, this certainly varies greatly, even within short distances. Near the north-west corner of the map it has probably a maximum thickness of two hundred feet, while on the north side of the Riding Mountain, where it was passed through in the Manitoba Oil Company's well on Vermilion River, it has, so far as can be determined from the few specimens at hand, a thickness of nineteen feet.

Extension.

South of this point these sandstones have not been recognized in natural exposures within the province, but they are again reported in the states to the south. Towards the north-west they would appear to be represented by the "Tar Sands" on the Athabasca River, but the formation has not yet been determined to be continuous throughout the intervening area.

Benton.

Dark gray shales.

Overlying the Dakota sandstones, the Benton formation occurs as a band of dark gray, almost black shale, holding a considerable quantity of carbonaceous material. This shale is evenly bedded, and breaks down readily into thin flakes, on which account it generally forms sloping banks. With the dark shales are associated thin beds of white, soft, sweet-tasting magnesian clay.

In the bore on Vermilion River, the Benton appears to be 178 feet thick, and further north, on the face of the Duck and Porcupine mountains, it continues of about the same, or slightly less, thickness. It is easily recognized, even when good naked exposures are absent, by its characteristic property of breaking into more or less minute graphite-like flakes, and not weathering immediately into a soft clay, as usually occurs in the less consolidated beds of the Pierre.

It is generally quite destitute of fossils, but in a few places undeterminable fragments of oysters and Inocerami have been collected from the shale.

Niobrara.

Mottled calcareous shale.

The Niobrara formation conformably overlies, and is an upward extension of, the Benton. The rock, however, instead of being a soft fissile shale, with little or no admixture of calcareous material, is a lighter gray calcareous shale or marl, sometimes varying to a band of moderately hard limestone. This is especially the case at the top of the terrane, where a band of grayish chalky limestone is generally met with. This band is often highly charged with pyrite.

A very characteristic feature of the formation is the presence of a Fossils large number of Foraminifera, among which *Globigerina cretacea* is often very conspicuous and in great abundance. From most of the exposures throughout north-western Manitoba, the species of foraminifera have not yet been authoritatively determined, but in specimens from Edwards Creek, and from a depth of 1,115 feet in the deep well at Deloraine, in southern Manitoba, the following species were kindly determined for me by Mr. C. Davies Sherborn, of London, England :—

- Globigerina cretacea*, d'Orbigny.
- " *bulloides*, d'Orbigny.
- " *linnaeana*, d'Orbigny.
- Cristellaria rotulata*, Lamarck.
- Planorbulina ammonoides*, Reuss.
- Anomalina rotula*, d'Orbigny.
- Bulimina variabilis*, d'Orbigny.
- Textularia globulosa*, Ehrenberg.
- Verneuilina triquetra*, d'Orbigny.
- Marginulina variabilis*, Neugeboren.
- Dentalina pauperata*, d'Orbigny.

Coccoliths and *Rhabdoliths* are also found in many of the specimens. With these minute forms may also occur in great abundance the fragments of shells of a large *Inoceramus* together with the following species :—

- Serpula semicoalita*, Whiteaves. N. sp.
- Ostrea congesta*, Conrad.
- Anomia obliqua*, Meek & Hayden.
- Inoceramus problematicus*, Schlotheim.
- Belemnitella Manitobensis*, Whiteaves. N. sp.
- Loricula Canadensis*, Whiteaves. N. sp.
- Ptychodus parvulus*, Whiteaves. N. sp.
- Lamna Manitobensis*, Whiteaves. N. sp. (loose.)
- Enchodus Shumardi*, Leidy.
- Cladocyclus occidentalis*, Leidy.

Very characteristic exposures of this formation may be seen in the Exposures valleys of all the streams on the north side of Riding Mountain from the Ochre to the Valley rivers, the highest cliffs being usually in the vicinity of some of the strongest of the old shore lines of Lake Agassiz. North of Valley River no outcrops of Cretaceous rocks were detected on the east face of Duck Mountain until North Pine Creek was reached. Here the foraminiferous Niobrara marls are again well exposed, and on Swan River and its tributaries, and on the streams flowing from the eastern and northern slopes of Porcupine

Mountain many excellent sections were discovered, so that these rocks form a clearly marked horizon in the middle of the Cretaceous of Manitoba. They generally weather into steep or vertical cliffs, and consist as a rule of gray calcareous shale, with a mottled appearance caused by the presence of large numbers of Foraminifera.

Thickness.

The terrane varies considerably in thickness. In the Manitoba Oil Company's bore on Vermilion River it appears to have a thickness of 130 feet. On North Pine Creek its total thickness is less than 400 feet, and probably is not more than 200 feet. On Bell River it is probably less than 250 feet. In the Swan River valley, near Thunder Hill, it would seem to have a thickness of 540 feet, but it is quite possible that the upper beds represent a foraminiferous horizon in the overlying Pierre formation.

Extension.

This terrane is known to extend southward through the western portion of the province of Manitoba, having been recognized in the valleys of the Assiniboine and other streams near the face of the Manitoba escarpment, and in the borings from the deep wells at Morden and Deloraine. It is doubtless continuous with the Niobrara shales and limestones, originally described by Messrs. Meek and Hayden, from the banks of the Missouri River in Nebraska. Northwest of the area now described, a fragment of typical Niobrara rock was collected from Carrot River, about west long. 103° , by Mr. A. L. Russell, beyond which it has not been traced, and its exact correlation with the beds on Athabasca River is not yet known.

Pierre.

Subdivisions.

Grading upwards from the top of the Niobrara formation the Pierre shales occupy the summits of all the higher lands of the Riding, Duck and Porcupine mountains. In the Riding Mountain and further south this formation naturally separates itself into an Upper and a Lower Subdivision, which the writer has elsewhere called the Millwood and the Odanah Series.* It is not improbable that the separation of these two series could also be traced northward through the Duck and Porcupine mountains, but that no sections exposing the Cretaceous were found in any of the higher parts of the country, or above the heights at which the Millwood Series might be expected to be found. This series is composed of dark grey soft clay shales very similar to those already described by Dr. Dawson, Mr. McConnell and the writer from Alberta and Assiniboa, containing crystals of selenite and septarian nodules of ironstone. Further west the Pierre is highly fossiliferous, but in north-western Manitoba fossils are very scarce, and of those recorded in the following

Millwood series.

* "The Cretaceous of Manitoba," by J. B. Tyrrell. Am. Jour. Sci., vol. 40, (1890) pp. 227-232.

list the Radiolaria are from a bed of shale on Bell River, and the remainder are from ironstone nodules from the west bank of the Assiniboine Valley at Millwood, a short distance south of the present map.

- Caryosphaera aequidistans*, Rüst. N. Sp.
Cenellipsis hexagonalis, " "
Prunulum calococcus, " "
Cyrtocalpis crassitestata, " "
Dictyocephalus microstoma, " "
 " *macrostoma*, " "
Theocampe sphaerocephala, " "
Tricolocapsa salva, "
 " *thoracica*, " N. Sp.
 " *Dowlingi*, " "
 " *Selwyni*, " "
Dictyomitra Canadensis, " "
 " *polypora*, Zittel.
 " *multicostata*, Zittel.
Stichocapsa Tyrrelli, Rüst. N. Sp.
 " *Dawsoni*, " "
Pteria linguiformis, Evans and Shumard.
Inoceramus tenuilineatus, Hall and Meek.
 " *Sagensis*, var. *Nebrascensis*, Owen.
Nucula sp.
Lucina occidentalis, Morton.
Entalis paupercula, Meek & Hayden.
Dentalium gracile ? "
Baculites compressus, Say.
Scaphites nodosus, var. *quadrangularis*, Owen.
Hylobites cretaceus, Scudder. N. Sp.
 Fragments of fishes.

These shales everywhere form the banks of the Assiniboine valley Outcrops from Fort Pelly southward, the river flowing on the strike of the terrane. They are also shown in high cliffs on the banks of Ochre and Vermilion rivers and Edwards Creek on the north face of Riding Mountain, the exposure on the latter stream showing the total thickness of the series. Further northward, on the eastern face of the escarpment, the Lower Pierre was recognized on North Pine and Bell rivers, in both of which places it was highly siliceous and contained large numbers of Radiolaria of the above-named species. For the rest the higher slopes are covered with drift.

These Millwood shales extend southward to the International Boundary, being seen at the foot of the bank at Minnedosa; in the valley of

Horse Creek west of Morden, and in many other places. Towards the north-west they have not yet been followed, but they are not improbably continuous with the similar dark shales on the Saskatchewan, and under large areas of the great plains.

Odanah series. The Millwood shales are overlaid by a considerable thickness of Upper Pierre light gray hard clay shales which are locally known as slate, and which, from their typical development at Odanah, near Minnedosa, on the Little Saskatchewan River, have been called by the writer the *Odanah Series*. Throughout the series are many beds of septarian ironstone nodules, but very few of these are compact like those in the Millwood series, and they are generally cut by many veins of crystalline calcite. No fossils were found by the writer in these shales, but Professor H. Y. Hind, in 1858, collected some fossils from beds of this series, near the mouth of Two Creeks, in township 13, range 27, which clearly show that these shales belong to the marine Cretaceous Pierre formation.*

The following is a list of these fossils:—

- Anomia Flemingi*, Meek.
- Inoceramus Canadensis*, Meek.
- Yoldia Hindi*, Meek.
- Lunatia obliquata*, Hall and Meek.
- Cinulea concinna*, Hall and Meek.
- Ammonites*, sp undet.

Character.

The cliffs of this terrane generally weather with a more or less sloping surface, but in railway cuttings, or by some streams, where erosion is very rapid, they rise almost vertically, presenting a general lead-gray appearance. The beds are also much fissured, and iron stains are everywhere seen along the lines of fissure. On a fresh surface the shale can be readily cut, but it quickly hardens on exposure to the atmosphere, and the streams cutting through it have their banks strewn with lenticular pebbles derived from it. In some places, as in the valley of the Little Saskatchewan River near Minnedosa, alluvial beds of these pebbles are being used as ballast for the railway.

Outcrops.

The Odanah series is well shown in the upper part of the valley of Edwards Creek, where it conformably overlies the Millwood shales. Slight exposures are also seen on the upper parts of Vermilion River, and the bed of Ochre River is thickly strewn with pebbles derived from

*In a paper on "The Cretaceous of Manitoba" in Am. Jour. Sci., vol. 40, 1890, p. 230, the writer states that the above-named fossils are probably from the Millwood series, but since that paper was written he has carefully examined the banks of the Assiniboine near where these fossils were collected, and has also examined the fossils themselves in the Museum of the Geological Survey of Canada. He is therefore now able to say definitely that the character of the rock in which they are imbedded proves them to be from the Odanah series or Upper Pierre.

it. Pebbles of this shale are first washed into the Assiniboine valley near the mouth of Skunk Creek, and a well at Barnardo's farm near Russell is stated to have been sunk 170 feet through these shales to the underlying series.

Fifty miles down the Assiniboine valley below the southern edge of Extension, the present map, these shales become conspicuous along its sides, and for thirty-five miles, or to opposite Griswold, the banks are more or less formed of them, and barren rounded knolls, too sterile to grow more than a few small cactus plants (*Opuntia Missouriensis*), rise from the low lands at the bottom of the banks. The valley here has a certain resemblance to the "Bad Lands" of the States to the south-west. This shale is also seen in the higher railway cuttings to the west of Minnedosa. Further south a beautiful section of these shales may be seen in the Pembina valley near La Rivière, on the Pembina Mountain branch of the Canadian Pacific Railway.

The total thickness of the Pierre in north-western Manitoba is 800 Thickness. feet or more. The Millwood series, as seen in the valleys on the northern face of Riding Mountain, has a thickness of between 450 and 500 feet, while about 300 feet of the overlying Odanah series is there also seen, reaching to near the summit of the mountains, and being immediately overlain by the drift deposits. The top of the Odanah series is not seen.

At the village of Deloraine, in south-western Manitoba, and close to the northern face of Turtle Mountain, the tank well on the Pembina Mountain branch of the Canadian Pacific Railway strikes the Odanah shales at a depth of about ninety feet, and a deep well close by it does not strike the Niobrara until a depth of 1,050 feet is reached, giving a thickness for the Pierre of 960 feet. At the foot of Turtle Mountain, a horizontal band of hard gray calcareous sandstone crops out, and assuming this to represent the base of the Laramie, though no fossils have yet been recognized from it, the whole thickness of the Pierre would be given as a little more than 1,050 feet. Considering the Millwood series as having a thickness of 650 feet, a thickness of about 400 feet would remain for the Odanah series.

PLEISTOCENE.

At the close of the Cretaceous epoch, north-western Manitoba Post-Cretaceous erosion. rose above the sea which had covered it since Dakota times, and which had left it mantled with a great series of sands and clays. A period of denudation then set it and continued throughout the whole of the Tertiary epoch. During this time the high table land of the Duck and Riding mountains was cut through by the valleys of the

Red Deer, Swan and Valley rivers, and the great valley of the Winnipeg basin, extending from the Manitoba escarpment to the Archæan nucleus, was formed by a river which may have been similar in size and character to the Mississippi of to-day. From this valley the Cretaceous rocks were almost entirely denuded down to the underlying floor of Palæozoic limestones. The trend of the afferent valleys, and the positions of the points of Cretaceous rocks on the edge of the escarpment, would appear to indicate that the main stream flowed north-westward.

Such was the shape of the country at the beginning of the Glacial period, when a great snow-field appears to have formed on the country around and to the north and east of Reindeer Lake, and the ice appears to have flowed in great glaciers westward through the basin of Lake Athabasca, southward across the plains, and south-eastward up the valley of the ancient river of the Winnipeg basin.

Glacial striae. Among the evidences of the course followed by this glacier, or these glaciers, across the region under consideration, the following list of glacial striae is particularly important. Most of these are strongly marked on the highest parts of level polished surfaces of Palæozoic limestone, and the direction of glacial movement is often shown by curved chatter-marks and cross fractures, &c.

Fairford	S. 33° E.
Flat Rock Bay, Lake Manitoba	S. 10° E.
Steep Rock Point, Lake Manitoba	S. and S. 13° E.
Little Sandy Point, Lake Manitoba	S. 10° E. and S. 10° W.
Onion Point, Lake Manitoba	S.
Granite Island, Lake St. Martin	S. 33° E.
South end Lake Winnipegos, near Meadow Portage	S. 63° E.
South end Lake Winnipegos, near Mossy River	S.
Charlie Island, north end, Lake Winnipegos	S. 2° E.
Charlie Island, east side, Lake Winnipegos	S. 8-13° E.
Charlie Island, (obscure,) Lake Winnipegos	S. 37° W.
Weston Point Island, Lake Winnipegos	S. 2° E.
South Manitou Island, Lake Winnipegos	S. 12° W.
Lat. 52° 45', E. side Lake Winnipegos	S. 9° W.
Long Point, Lake Winnipegos, several places	S. 22° W.
Long Point, Lake Winnipegos, one place	S. 8° E.
Ami Island, Lake Winnipegos	S. 23° W.
S.W. side Cameron Bay, Lake Winnipegos	S. 43° W.
Rowan Island, Dawson Bay, Lake Winnipegos	S. 42° W.
Beardy Island, Dawson Bay	S. 58° W.

Rose Island, Swan Lake.....	S. 48-53 W.
McKay Island, Swan Lake and islands to the south.....	S. 53 W.
Red Deer River, $\frac{1}{2}$ mile below Upper Salt Spring.....	S. 78 W.
Red Deer River, Upper Salt Spring.....	S. 68 W.
Red Deer River, Pelican Rapids.....	S. 78 W.
Saskatchewan River, Grand Rapids, bottom.....	S. 2 W.
Saskatchewan River, Grand Rapids, middle.....	S. 62 W.
Saskatchewan River, Grand Rapids, middle (second set.), ..	S. 92 W.
Saskatchewan River, below Roche-rouge.....	S. 12 W.
Saskatchewan River, Roche-rouge.....	S. 12 W.
Cedar Lake, south-east shore.....	S. 19 W.
Cedar Lake, Island east of Rabbit Point.....	S. 18 W.
Cedar Lake, mouth of Saskatchewan River.....	S. 39 W.
Cedar Lake, mouth of Saskatchewan River, one groove....	S. 65 E.
Assiniboine River, Sec. 16, Tp. 25, R. 29, on boulders in boulder pavement.....	S. 73 E.

The surface is very generally covered with till, which on the lacustral plain, over the hard Palæozoic limestones, does not appear to be anywhere of great depth; but on the summit of the Cretaceous plateau to the west, where the rocks consist entirely of soft shales, the till would seem to be very much deeper. In most places it immediately overlies the Cretaceous shales, but in some excellent exposures on Rolling River it is seen to be underlaid by seventy feet or more of stratified sands and clays which are probably of Interglacial age. The Interglacial beds contain the following species of plants and freshwater shells:—

Diatomaceæ.

- Navicula lata.*
- Encyonema prostratum.*
- Denticula lauta.*
- Licmophora?*
- Cocconeis.*

Phanerogamæ.

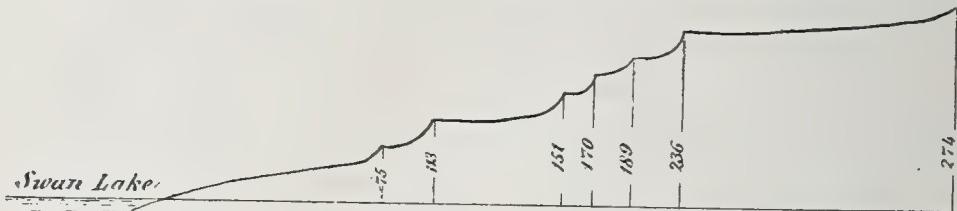
- Taxus baccata.* L.
- Seeds of a Conifer.*
- Elodea Canadensis (?)* Michx.
- Vallisneria (?)*

Mollusca.

- Lymnaea catascopium?* Say. Variety with very short spire.
- Valvata tricarinata,* Say., and a keelless variety.
- Amnicola porata?* Say.
- Planorbis bicarinatus,* Say.
- “ *parvus?* Say.
- Pisidium abditum,* Haldeman.
- Sphaerium striatinum,* Lamarck.

Lake shores.

On the summit of the Cretaceous plateau the till is covered in a number of places by lake deposits, and east of the escarpment the ancient beaches of Lake Agassiz form long lines of parallel gravel ridges. In some places the ancient lake shores are represented by terraces, cut in the glacial or Cretaceous deposits. An interesting series of these terraces may be seen on the north side of Kettle Hill, south of Swan Lake, as shown in the following figure:—



Section of Kettle Hill south of Swan Lake.

Horizontal Scale. 3000 ft. to an inch.

Vertical Scale. 300 ft. to an inch.

A small amount of lacustral sand and clay is occasionally present on the surface, but as a rule, throughout the greater portion of this district, the old lake floor is composed of till.

Moraines.

Moraines are also present at the Mossy Portage and on and around the "mountains," and will be found more particularly described in the descriptive portion of this report.

The glacial and post-glacial deposits of this region will, however, be more fully discussed in the forthcoming report on Lake Winnipeg.

ECONOMIC GEOLOGY.

Salt.—The presence of brine springs is a well-marked feature of the Brine springs. Devonian area west of Lakes Winnipegosis and Manitoba; but while the most copious supply of brine flows from the Devonian rocks, chiefly marking the base of the Upper Devonian, salt is not absent from the beds of Silurian age, and many slabs of this rock were found showing beautiful moulds of typical crystals of Chloride of Sodium. A few small springs of clear salty water were found flowing from the Silurian area on the west side of Winnipegosis. Careful search was made everywhere for indications of the presence of beds of pure salt, but none were found, and instead, impressions of salt crystals were common in all the more porous dolomites. It is probable, therefore, that the salt occurs entirely in more or less isolated crystals scattered throughout the rock, but in some cases these are so numerous that at least a third of the whole mass has been salt.

The following are some of the principal places where brine springs Localities. have been observed :—

1. Salt Creek, west of Lake Dauphin.
2. Banks of Mossy River.
3. Salt Point, south end Lake Winnipegosis.
4. Monkman's Salt Springs, Red Deer Peninsula.
5. Pine Creek.
6. Pelican Bay, mouth of Pelican Creek.
7. " " west side.
8. Mouth of Bell River.
9. Salt Point.
10. Salt Point Peninsula, wide salt area near its base.
11. Salt Point Peninsula, north side of its base.
12. Mouth of Steep Rock River.
13. Lower Red Deer River, many places.
14. Banks of Shoal River.
15. Mouth of Swan River.

At many other places near the line of the base of the Upper Character of Devonian, small saline areas occur, where the brine oozes up through saline areas. the overlying drift. The characters of these saline areas are very similar throughout, and the descriptions already given of those on Pelican Bay and other places might suffice for all. They are generally barren tracts several acres in extent, surrounded by a fringe of the red salt plant (*Salicornia herbacea*). Here and there springs bubble up and often build rounded mounds of reddish scinter, several feet in height, in the centre of the tops of which, over the springs, are little basins of clear brine. Down the sides of these mounds the water trickles

to the arid flats, where it evaporates in the dry seasons. In other places the pool of salt water is in the middle of a little tract of soft mud, over which may be a sod of coarse grass. In the pool bubbles of gas are constantly rising. This gas was found to be uninflammable, and was probably to a large extent composed of air.

Some of the springs mentioned above were used for the manufacture of salt in the early days of the Red River Settlement, and even yet the Indians occasionally boil down a little salt from them.

Monkman's
Salt Works
in 1858.

The following excellent description of Monkman's Salt Works, as they existed in 1858, is given by Prof. H. Y. Hind :—*

"The soil at the Salt Springs is a very retentive yellowish white clay, containing small limestone boulders and pebbles, with boulders of the unfossiliferous rocks. The wells, for obtaining a supply of brine, are sunk wherever a small bubbling spring is observed to issue from this retentive clay. The springs are constantly changing their position, and as the wells become exhausted from time to time, a fresh excavation is made where a new spring is observed to issue. No doubt boring, or deeper wells, would prevent these changes, and not only secure a larger flow of brine, but ensure its permanency. The wells at present are 25 in number; but some of them appear to have been lately abandoned, and others have long since ceased to yield brine. They are situated 400 yards from the lake shore, and were first worked 40 years since, by James Monkman. This enterprising individual struggled for many years against the importation of English salt, which was sold in the settlements at a cheaper rate than he could afford to manufacture salt on Lake Winnipegosis. He has made salt at Swan River and Duck River. The manufacture is now carried on with profit for the Hudson's Bay Company, at Swan River, and at Winnipegosis Lake by Monkman's sons.

"At the 'Works' there are two small log-houses and three evaporating furnaces. The kettles, of English construction, are well made rectangular vessels of iron, five feet long, two feet broad and one foot deep. They are laid upon two rough stone walls, about twenty inches apart, which form the furnace. At one extremity is a low chimney. The whole construction is of the rudest description; and at the close of the season the kettles are removed, turned over, and the furnace permitted to go to ruin, to be rebuilt in the following spring.

"The process of making salt is as follows: When a spring is found, a well, five feet broad and five feet deep, is excavated, and near to it an evaporating furnace erected. The brine from the wells is ladled into the kettles, and the salt scooped out as it forms, and allowed to remain

*Op. cit., pp. 94 and 95.

for a short time to drain before it is packed in birch bark roggins for transportation to Red River, where it commands twelve shillings sterling a bushel, or one hundred weight of flour, or a corresponding quantity of fish, pemican or buffalo meat, according to circumstances.

"The brine is very strong. From one kettle two bushels of salt can be made in one day in dry weather. There are nine kettles at the 'Works,' seven being in constant use during the summer season. The half-breeds engaged in the manufacture complained of the want of fuel—in other words, of the labour and trouble of cutting down the spruce and poplar near at hand, and the difficulty of hauling it to the furnaces. An objection of no moment, but characteristic of some of the people, who are generally unaccustomed to long-continued manual labour. Unfortunately, I had no instrument with me for ascertaining the specific gravity of the brine, and a supply which I took to Red River for that purpose, as well as with a view to its analysis, still remains in the settlements. It will be seen that the processes employed in the manufacture of salt are of the rudest description, so that without any outlay beyond a few days' labour, the quantity might be largely increased. I spoke to John Monkman, who now makes salt here, of pumps and solar evaporation. Of a pump he knew absolutely nothing. He had heard that such an apparatus had been contrived, but had never seen one. He readily comprehended the advantage to be derived from pumping the water into shallow troughs, dug in the retentive clay near the springs, and strengthening the brine by solar evaporation."

At the present time the cost of carriage of salt from Ontario renders it very expensive in Manitoba, and the large development of the fishing industry on Lake Winnipeg, and its probable extension to the other lakes of the North-West, renders the question of obtaining an abundant local supply at a reasonable cost one of great importance.

Importance of
the salt indus-
try to
Manitoba.

As is shown below the natural brines of Manitoba are not very strong but the supply is large, and the dry climate would be very favourable to their concentration by solar evaporation, which at the same time would remove some of their impurities, and the forests in the immediate vicinity of the springs would furnish an abundant supply of fuel for boiling down the concentrated brine.

Brines were collected from most of the important springs throughout this portion of the country, and have been analysed by Mr. G. C. Hoffmann, of this Survey.* The following table gives in synoptical form the result of his examination:—

Analyses of
brines.

* Geol. Sur. Can., Ann. Rep. Vol. V., 1889-90-91, pp. 26 R.—37 R.

ANALYSES OF BRINES FROM MANITOBA.
 The following Table shows the number of grains per Imperial gallon of each of the chief constituents entering into the composition of these Brines.

Constituents.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Chloride of sodium	3426·61	2777·44	3402·38	3716·73	3884·57	3673·23	6024·98	3233·15	3709·59	1873·78	1347·08	3099·41
do potassium	163·86	114·59	209·39	180·21	137·90	145·16	86·17	138·81	179·86	150·16	48·72	23·11
do calcium	28·45	101·75	85·69	47·43	94·66	125·46	7·87	10·43	15·67	15·67	44·05	
do magnesium	77·17	101·16	101·75	394·96	272·81	300·30	6·49	78·03	81·46	79·84	58·53	142·22
Sulphate of lime	285·83	233·72	296·23	57·30	1·24	19·42	19·42	19·42	10·98	205·53	204·33	252·71
do magnesia	3·42	3·42	3·42	3·42	3·42	3·42	3·42	3·42	3·42	3·42	3·42	3·42
Total	3956·89	3255·37	4010·99	4294·08	4400·01	4221·22	6081·28	3742·32	4290·27	2324·98	1670·11	3561·50
Specific gravity	1·039	1·032	1·039	1·041	1·041	1·041	1·041	1·033	1·035	1·039	1·022	1·016
												1·035

1. Spring on the south bank of Red Deer River, four miles from Lake Winnipegosis. N. lat. 52° 52' 30"; W. long. 101° 5'. Flow, 10 gallons a minute. Collected, 9th September, 1889.

2. Lower Salt Spring, on the north side of Red Deer River, a mile and three-quarters above its discharge into Lake Winnipegosis. N. lat. 52° 53' 20"; W. long. 101° 2' 15". Flow, 2 gallons a minute. Collected, 13th August, 1889.

3. Spring near the west shore of Dawson Bay, Lake Winnipegosis, three-quarters of a mile north of the mouth of Steep Rock River. N. lat. 52° 48' 30"; W. long. 100° 55'. Flow, 4 gallons a minute. Collected, 6th August, 1889.

4. Spring on a hillside near the shore of Dawson Bay, Lake Winnipegosis, at a point two miles east of the mouth of Steep Rock River. N. lat. 52° 48' 30"; W. long. 100° 57'. Flow, 25 gallons a minute. Collected, 8th August, 1889.

5. Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis. N. lat. 52° 48' 48"; W. long. 100° 48'. Flow, 1½ gallons a minute. Collected, 3rd August, 1889.

6. Spring on the west side of Dawson Bay, Lake Winnipegosis, three miles and a-half north of the mouth of Bell River, and a mile back from the lake shore. N. lat. 52° 48'; W. long. 100° 51' 20". Flow, 20 gallons a minute. Collected, 2nd August, 1889.

7. Brook flowing into the west side of Dawson Bay, Lake Winnipegosis. N. lat. 52° 47' 40"; W. long. 100° 51'. Flow, 60 gallons a minute. Collected, 1st August, 1889.

8. Spring half a mile back from the west shore of Swan Lake, between it and the lower portion of Swan River. N. lat. 52° 38' 30"; W. long. 100° 42' 45". Flow, 5 gallons a minute. Collected, 31st August, 1889.

9. Spring on the shore of Pelican Bay, Lake Winnipegosis, just east of the mouth of Pelican Creek. N. lat. 52° 47' 35"; W. long. 100° 42' 45". Flow, a minute. Collected, 21st July, 1889.

10. Spring on the west side of Pine Creek, near its discharge into Lake Winnipegosis. N. lat. 52° 1'; W. long. 100° 8'. Collected, 6th July, 1889.

11. Monkman's Salt Springs, on the west shore of Lake Winnipegosis. N. lat. 51° 45'; W. long. 99° 56' 40". Collected, 1st July, 1889.

12. Monkman's Salt Springs. An old well a few yards from the spring from which No. 11 was obtained. Collected, 1st July, 1889.

Speaking of these brines, and of the various methods pursued in the manufacture of salt, Mr. Hoffmann says :—*

“The proportion of foreign saline matters in these brines is not excessive, and if certain purifying processes are had recourse to, there is no reason—local conditions being favourable—why they should not be utilized in the manufacture of salt.

“The following brief outline of the methods pursued in the preparation of salt from its solutions, will serve to convey some idea of the expedients resorted to for the economical treatment of the weaker salt waters. The processes may be arranged under the following headings :

1. Those in which evaporation is entirely effected by artificial heat :
2. Those dependent upon natural evaporation—either wholly or in part :
3. That in which concentration is effected by congelation—with subsequent recourse to artificial heat.

“1. By artificial evaporation.

“The manufacture of salt from its solutions by evaporation with artificial heat, is conducted either in large shallow iron pans—as in Cheshire, Worcestershire, and Staffordshire—or in kettles—as at the Onondaga salines and elsewhere. The heating being in both instances effected by fires placed beneath.

“2. By natural evaporation—either wholly or in part.

“(a) By the influence of the sun, aided by that of the air—solar evaporation. This method is resorted to in the preparation of salt from sea water, on the shores of the Mediterranean, some parts of the English and Scottish coasts, and in some localities on the Atlantic and Pacific coasts of the United States. The evaporation is carried on in a series of shallow ponds or basins in which the water is spread over a very large surface. These reservoirs, which are excavated on the sea shore, are generally puddled with clay, but on the Bay of San Francisco the better grade of salt is prepared in ponds which are provided with wooden floors, or wholly inclosed with boards, and when a specially pure salt is required, the cleanest of the brine is transferred to, and the evaporation completed in, wooden tanks. When solar evaporation is pursued in the manufacture of salt from natural brines, the process is conducted in a series of shallow wooden vats, arranged in tiers, provided with movable covers running upon rollers for use during rainy weather. The brine is let into the upper tier of vats and from thence is allowed, at different stages of alteration, to pass on until it ultimately arrives—having in the interval deposited and suspended nearly all the less soluble impurities, and lost a large proportion of its water by evaporation—as a clear saturated brine, in the lower tier of vats where the formation of salt goes on.

Outlines of methods pursued in the preparation of salt from its solutions.

Natural evaporation.

*Geo. Survey Can., Ann. Rep., Vol. V., pt. R., pp. 36 and 37.

Natural
evaporation—
Con.

"(b) By exposure to a current of air—the 'graduation' process. A method employed, among other places, at Montiers in France, and at Nauheim, Dürrenberg, Rodenberg, and Schönebeck, in Germany, in the preparation of salt from weak brines. The process is carried on in what are termed 'graduation-houses.' These are large wooden structures covered over at the top to exclude rain, but left open at the sides to allow of free circulation of air through the building. The interior arrangement may, in a general way, be described as consisting of a large shallow wooden cistern, for the reception of the brine, over which are arranged bundles of brushwood or thorns built up in the form of a wall between wooden supports, and over this a reservoir for the weak brine. The saline water is pumped into the upper reservoir and thence allowed to trickle down over the surface or through the interstices of the thorns, thereby exposing it, diffused over a very large surface, to the influence of the air and effecting its concentration. The operation is repeated as often as may be found necessary for the conversion of the weak into a strong brine.

"The success of these two processes, solar evaporation and 'graduation,' being altogether dependent upon the state of the atmosphere, their use is consequently limited to the more favourable time of the year.

Congelation.

"3. By congelation.

"In some parts of Northern Europe the separation of salt from sea water is, in part, effected by the agency of frost—salt water when partially frozen separating into ice, retaining very little salt, and a proportionately stronger saline liquor. So that by submitting sea water, contained in reservoirs, to repeated partial congelations and removing the ice as it forms, each successive mother liquor becomes more and more impregnated with salt, until at length the solution attains the strength of a saturated brine.

"The process dependent upon evaporation with artificial heat is usually only resorted to in the treatment of strong brines, but where cheap fuel can be obtained the same plan is pursued with the waters of the weaker springs, and sometimes, though rarely, even with sea water. When fuel is scarce the more diluted saline waters cannot be profitably worked in this way, and these can, therefore, only be utilized by resorting to one of the processes of natural evaporation—solar evaporation or that by 'graduation.' The salt may, by either of these methods, be prepared without the aid of artificial heat, as is customary in the preparation of 'bay-salt' and 'solar-salt,' and is also the practice at the 'graduation-works' at Montiers, in France, or the weak brine may be brought to the point of saturation and further evapora-

tion effected with artificial heat. The concentrated liquor obtained by the repeated partial freezing of a weak salt water, is treated as a strong brine, the salt being obtained from it by artificial evaporation."

"*Amber*," or *Chemawinite*.—This interesting mineral was found in "Amber," pieces from the size of a robin's egg downwards, on sandy beaches on the west side of Cedar Lake, a short distance south of the Saskatchewan river. The shore is low and shelving, and the beach runs along the face of a deep wet spruce swamp, the "amber" being everywhere mixed with many small fragments of partly decayed wood. The swamp behind is stated to be underlaid by a compact till with boulders.

The most important beach is a little less than a mile in length, and from 80 to 120 feet in breadth. The "amber" is found most plentifully along its ridge, where it constitutes about ten per cent by volume of the sand and woody debris, and holes dug to a depth of two feet showed little or no diminution in its quantity. A number of samples collected from various parts of the beach showed an average of a little more than ten per cent of "amber," which, in natural fragments, weighed forty-six pounds to the cubic foot. The size of the beach were roughly estimated at 316,800 cubic feet, which would yield about 31,680 cubic feet, or 1,457,280 pounds of "amber." It has probably been washed by the river from some cliff or cliffs of Cretaceous clay or sand higher up the stream, and has been carried down and deposited in the marshy and swampy delta west of Cedar Lake. From this delta deposit, it is now being washed out from time to time by the waves of the lake and thrown up on the beach.

Prof. B. J. Harrington, of McGill College, Montreal, has described this mineral and the following are some extracts from his paper :—*

"The substance was in pieces, for the most part very irregular in shape, some being more or less angular, others approximately spherical, and others flattened, discoid or lenticular. Some of the pieces were smaller than a pea, but they ranged from this up to the size of an ordinary bean (about 2 centimetres long). In colour they varied from pale-yellow to dark-brown, and many, when examined by transmitted light, appeared clouded or banded from the presence of black carbonaceous matter. Superficially they were generally dull, owing, perhaps, to chemical change, but on fresh surfaces the lustre was resinous. The fracture was conchoidal. Though electric on friction, they appear to be less strongly so than ordinary amber.

"Light-coloured fragments, free from black carbonaceous matter, were selected for examination, and any superficial crust carefully removed by scraping. The hardness of these selected pieces was fully $2\frac{1}{2}$. The specific gravity, as obtained with a quantity of material in the specific gravity bottle, was 1.055 (at $20^{\circ}\text{C}.$), and a single fragment gave by suspension with a hair 1.0543 ($20^{\circ}\text{C}.$)

Dr. Harring-ton's descrip-tion.

* American Journal of Science, Vol. XLII., Oct. 1891, pp. 332-335.
15

"The material for analysis was finely powdered and dried over sulphuric acid *in vacuo*. The combustions were made with lead chromate in the usual way, and the ash determined with a separate portion in a platinum crucible.

Results of analyses.

"The following are the results obtained :—

	I.	II.	Mean.
Carbon.....	80·01	79·91	79·96
Hydrogen.....	10·37	10·55	10·46
Oxygen.....	9·53	9·45	9·49
Ash.....	0·09	0·09	0·09
	100·00	100·00	100·00

Excluding the ash the results become :—

	I.	II.	Mean.
Carbon.....	80·08	79·98	80·03
Hydrogen.....	10·38	10·56	10·47
Oxygen.....	9·54	9·46	9·50
	100·00	100·00	100·00

"The ash was brick-red in colour, and found to contain silica, alumina, iron, lime, and magnesia.

"The only solvents whose action upon the resin has been tried as yet are absolute alcohol and absolute ether, and the effect of these was ascertained as follows :

Action of solvents.

"One gram of the finely powdered resin was mixed with ten grams of pure quartz sand in a cylinder of filter paper and extracted in Soxhlet's apparatus, in the case of the alcohol for three and a half hours (24 siphonings) and in the case of the ether for two hours (24 siphonings). In each case the sand and filter paper were previously extracted by the special solvent for several hours. The extract from the resin was evaporated in a weighed platinum dish and the residue dried at 100°C. The results obtained were as follows :

	Per cent.
Dissolved by absolute alcohol.....	21·01
Dissolved by absolute ether.....	24·84

"The effect of more prolonged action of the solvents has not as yet been ascertained. The alcoholic extract after drying was brownish in colour, while that obtained with ether was only faintly yellow.

"When small fragments of the resin were heated in closed tubes it softens with heat. It was found that they began to soften at about 150°C., the point of softening being roughly ascertained by pressure with a platinum rod. At 180-190°C. the fragments were sufficiently yielding to be pressed into one mass by the platinum rod. Heated up to 300°C., the resin did not melt into a flowing liquid, but became soft and elastic, and had darkened a good deal from partial decomposition.

"Fragments of genuine amber behaved in a similar manner, but began to soften at about 140°C. At 180° they could be readily pressed into one mass, and in the one experiment tried they seemed to darken more readily than the Cedar Lake resin when heated up to 280-300°C. The ordinary statement that amber fuses at 287°C is certainly misleading, the fact being that it begins to soften at a very much lower temperature, gradually getting softer and softer as the temperature rises, but not becoming a flowing liquid until decomposition takes place.

"On heating the Cedar Lake resin in a test tube or retort no crystals of succinic acid were obtained, although they were readily obtained from true amber by similar treatment.

"It is customary to assign to amber the formula $C_{40}H_{64}O_4$, which formula gives: carbon 78·94, hydrogen 10·53, oxygen 10·53; but this is apparently based upon very insufficient data—so far as the writer is aware, upon the single analysis of Schrotter (carbon 78·82, hydrogen 10·23, oxygen 10·95), which really corresponds much more closely to $C_{39}H_{60}O_4$. Such a substance as amber, too, coming from a variety of localities and originally derived from very different plants can scarcely be expected to agree closely in composition with one definite formula.

"The Cedar Lake resin contains more carbon than the amber analysed by Schrotter and less oxygen, and in this respect comes nearer to Walchowite and to some of the recent copals from India. The relations of some of these bodies will be made plain by the following tables:

—	Car- bon.	Hydro- gen.	Oxy- gen.	Ratio of C, H, & O atoms.	Ratio of C, H, & O atoms, taking C = 40.
I. Amber	78·82	10·23	10·95	9·60 : 14·95 : 1	40 : 62·29 : 4·16
II. Krantzite	79·25	10·41	10·34	10·22 : 16·11 : 1	40 : 63·05 : 3·91
III. Cedar Lake Resin..	80·03	10·47	9·50	11·23 : 17·63 : 1	40 : 62·79 : 3·56
IV. Copal (Bombay)....	79·70	10·40	9·90	10·75 : 16·83 : 1	40 : 62·62 : 3·72
V. Copal (Calcutta)...	80·34	10·32	9·34	11·46 : 17·67 : 1	40 : 61·67 : 3·49

I. Phillips's Mineralogy (1852), p. 630. Anal. by Schrotter. II. Dana's Mineralogy (1869), p. 741. Anal. by Landolt. IV. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol. V. Watts's Dictionary of Chemistry (ed. i.), Vol. II., p. 19. Anal. by Filhol.

"Though resembling amber in some of its characters, the Cedar Lake resin may here be classed provisionally as "retinite," on account of its differing from amber in its deportment with solvents, in not yielding crystals of succinic acid on distillation, and in having a somewhat different ultimate composition. The name retinite as used by some mineralogists is a convenient general term to include such substances as Walchowite, Krantzite, Jaulingite, Rosthornite and the Cedar Lake resin, which last, by way of distinguishing it from other retinites, may be called Chemawinite (from Chemahawin or Chemayin, the Indian name of a Hudson Bay post, not far from where the resin occurs).

Origin.

"Though the origin of this substance is not certainly known, there can be little doubt that it has been derived from one of the Tertiary or Cretaceous lignites occurring on the Saskatchewan. Some of these are known to contain resins, one of which, examined by the writer, was not essentially very different from the Cedar Lake material. It behaved similarly on heating, had a hardness of over 2, a specific gravity of 1·066, and dissolved in absolute alcohol to the extent of 29·30 per cent.

Uses.

"Some of the larger pieces of the Cedar Lake resin might, perhaps, be employed for ornamental purposes (beads, &c.), and possibly the material might be utilized by the varnish-maker."

Nodules of carbonate of iron.

Iron.—Nodules of Carbonate of Iron are present in considerable numbers in the Pierre shales, both on the north side of Riding Mountain and in the banks of the Assiniboine Valley. They were nowhere seen in sufficient quantity to be of any economic importance. A specimen collected by Dr. Bell from the crossing of White Sand River, was found by Mr. G. C. Hoffmann to contain 34·07 per cent of metallic iron.*

Lignite.

Coal.—Lignite was found in the form of carbonized masses of wood or tree trunks, lying in the Benton shale on Swan River, and also in small quantity in the Niobrara shale on Wilson River. The following is a description and analysis by Mr. G. C. Hoffman of a specimen from the former locality:—†

"**LIGNITIFIED WOOD.**—From Swan River, Manitoba, township 37, range 26, west of the Principal Meridian.

"Has a clear and wood-like structure; colour black, with a faint brownish tinge; lustre dull, that of a freshly fractured surface resinous; fracture uneven, occasionally sub-conchoidal; hard and tough; does not soil the fingers; powder brownish-black; it communicates a deep brownish-red colour to a boiling solution of caustic potash; by exposure to the air becomes fissured.

* Rep. of Prog. Geol. Sur., Can., 1875-6, p. 431.

† Ann. Rep. Geol. Sur. Can., Vol. IV., N.S., 1888-9, p. 6 R.

"Analysis by fast coking gave :—

Hygroscopic water	9·66
Volatile combustible matter	43·16
Fixed carbon	43·61
Ash	3·57
	—
	100·00

Coke, per cent..... 47·18

"Ratio of volatile combustible matter to fixed carbon, 1: 1·01. It yields a loose friable coke ; the gases evolved during coking, burnt with a yellowish, somewhat luminous, slightly smoking flame. The ash has a pale brownish-yellow colour,—it is readily fusible at a bright red heat, running into a fluid slag."

Similar lignite was found lying in fresh fragments on the shore of Gypsum. Pemmican Island, having been washed up by the waves from a bed beneath the surface of the lake. This bed is doubtless of Cretaceous age, probably at the horizon of the Dakota formation.

Gypsum.—An extensive deposit of gypsum and anhydrite was found in the Silurian area a short distance north-east of Partridge Crop Lake, and a bed of gypsum fifteen feet in thickness was also passed through in the middle of the Upper Devonian limestones at a depth of 560 feet in the deep well on Vermilion River.

Phosphatic Shale.—A small deposit of phosphatic shale, containing a large number of fragments of the bones of fishes, outcrops on the banks of Wilson River in Section 18, township 25, range XX. The bed may be extensive, but at the time it could not be traced for any considerable distance. Mr. Hoffmann found it to contain 17·27 per cent of phosphoric acid, equivalent to 37·7 per cent of tribasic phosphate of lime. If the bed proves to be extensive it may be utilized as a fertilizer in the same way as the coprolite beds are used in England and France. Throughout all the Niobrara shales, however, these fish remains are present in small quantities, and add greatly to the richness of the soils formed by their disintegration.

APPENDIX.

List of photographs taken during the course of the explorations in the summers of 1887-90. Uniform size $6\frac{1}{2} \times 8\frac{1}{2}$ inches.

1887.

1. Valley of the Little Saskatchewan River at Strathclair, Man. July 19.
2. Lake Audet, in the Riding Mountain at the head of the Little Saskatchewan River, Man. July 21.
3. Willow-covered plain by Edward's Creek, Man. July 25.
4. Beach of Lake Dauphin, Man. July 26.
5. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking up the stream.
August 8.
6. Valley River, in Sec. 11, Tp. 24, R. 21, W. Man., looking down the stream.
August 8.
7. Bank of Drifting River, from gravel ridge east of Duck Mountain, Man.
August 9.
8. Face of gravel ridge on north side of Fork River, Man. August 11.
9. "Pitching ridge," north of Valley River, Man. August 16.
- 10 and 11. Views up and down Valley River from the top of one of the highest of the gravel ridges east of the Duck Mountain. August 18.
- 12 and 13. Sides of valley of Valley River, Man., showing old Indian houses.
August 19.
14. Morainic ridge, two miles below the mouth of Short Creek, on the Valley River, Man. August 20.
15. North end of Shoal Lake, in Tp. 17, R. 23, W. Man. August 26.
16. Noon camp, at the trail crossing of Silver Creek, in Tp. 20, R. 27, W. Man.
August 31.
17. Silver Creek, in Tp. 20, R. 27, W. Man. August 31.
18. Village of Russell, Man. September 1.
19. Small lake south of the Angling Lake trail, on Duck Mountain, Man.
September 6.
20. One of the Angling Lakes, on Duck Mountain, Man. September 7.
21. Indian Village, near Angling Lakes, Duck Mountain, Man. September 10.
22. Shell River, near trail to Côté's Reserve, Man. September 18.
23. Shell River, in latitude $51^{\circ} 35'$, Man. September 19.
25. Northern Pocket Gopher (*Thomomys talpoides*, Rich.) natural size. Shell River, Man. September 19.
25. Marsh near Fort Pelly, Assa. September 24.
26. Swan River, looking from the Square Plain, Man. September 29.
27. Swan River, from mouth of Oak Creek, Man. October 16.
28. Saulteux Indians from the Upper Assiniboine River. October 16.
- 29 and 30. Second crossing of Swan River, Man., opposite the old store-house of the H. B. Co. October 18.

31. Poplar forest at second crossing of Swan River, Man. October 24.
 32 and 33. Valley of Swan River at the Upper Crossing, north-east of Fort Pelly, Assa. October 30.
 34. Swan River, from old Police Barracks, Assa. October 31.
 35. Valley of Snake Creek, Assa., looking across. October 31.
 36. Valley of Snake Creek, Assa., looking down. October 31.
 37. Fort Pelly, Assa. November 1.
 38. Stopping Place, on the trail from Russell to Fort Pelly. November 3.
 39. Valley of Big Boggy Creek, at the crossing of the Russell and Fort Pelly trail. November 4.

1888.

40. Steep Rock Point, Lake Manitoba. July 1.
 41. Camp of Saulteaux Indians on the shore of Lake St. Martin, Man. July 4.
 42. Chief Wekemowskunk, and family, Lake St. Martin, Man. July 4.
 43. Chief Wekemowskunk building a canoe, Lake St. Martin, Man. July 4.
 44. Island of red granite in Lake St. Martin, Man. July 4.
 45. Waterhen River, Man. July 18.
 46. Pile of boulders on Twin Islands, Lake Manitoba. July 18.
 47. Monroe Point, Lake Manitoba. July 20.
 48. Horse-shoe harbour, Manitoba Island. July 26.
 49. Onion Point, Lake Manitoba. August 1.
 50. Big Sandy Point, Lake Manitoba. August 2.
 51. Small stony island, with young Cormorants, Lake Manitoba. August 4.
 52. Steep Rock Point, Lake Manitoba. August 5.

1889.

53. Ruins of Old Trailing Post, near the Narrows of Lake St. Martin, Man. June 7.
 54. Narrows of Lake Manitoba, west side. June 12.
 55. Harbour on Cherry Island, Lake Manitoba. June 14.
 56. Mossy River, near the mouth. June 22.
 57. and 58. Cliff of limestone on Mossy River, just above the old C. P. R. crossing. June 23.
 59. Fork River, looking eastward towards Mossy River. June 25.
 60. Cliff of till and alluvial clay on Mossy River, just below Fork River. June 29.
 61. View down Mossy River, from near the same point. June 29.
 62. Brine spring at "Monkman's Salt Springs," Lake Winnipegosis. July 1.
 63. Well and ruins of old house on arid flat at "Monkman's Salt Springs." July 1.
 64. Erosiated surface of limestone on island off Weston Point, Lake Winnipegosis. July 2.
 65. Cliff of Manitoban limestone on Island off Weston Point. July 2.
 66. Limestone Cliffs at Point Brabant, Lake Winnipegosis. July 4.
 67. Point Brabant, Lake Winnipegosis, showing row of elm trees in front of the cliff. July 4.
 68. Steep beach of gravel showed up by the ice, north-west point of Birch Island, Lake Winnipegosis, July 13.
 69. Low cliff of limestone at the north end of Birch Island, Lake Winnipegosis. July 13.
 70. Cliff of dolomite hidden among the trees at the north end of Hill Island, Lake Winnipegosis. July 13.

71. Cliff of till 100 yards south of the north point of Hill Island, Lake Winnipegosis. July 13.
72. Our boat off beach of boulders, at the north end of Birch Island, Lake Winnipegosis. July 14.
73. Boulder wall, fifteen feet high, at the north-east end of North Manitou Island, Lake Winnipegosis. July 15.
74. Cliff of nodular dolomite at Devil's Point, Lake Winnipegosis. July 18.
75. Cormorants and pelicans on Cormorant Islands, Lake Winnipegosis. July 18.
76. Groove, ten paces long, in the mud and gravel on the beach, with boulders lying in the upper end of it. Looking S. 25° E., Pelican Bay, Lake Winnipegosis. July 20.
77. Same groove. Looking N. 25° W.
78. Boulder lying at the upper end of a long groove, with clay and irregular pebbles shoved up in front of it. Pelican Bay, Lake Winnipegosis. July 20.
79. Two boulders, lying at the end of a groove twenty-five paces long which runs N. 30° W. through the mud and stones of the beach. Looking south. Pelican Bay, Lake Winnipegosis. July 21.
80. Large boulder on the west shore of Pelican Bay, Lake Winnipegosis. July 22.
81. Irregular nodular limestone shoved up on the beach by the ice. Channel Island, Lake Winnipegosis. July 23.
82. Cliff of Manitoban limestone among the trees in Cameron Bay, Lake Winnipegosis. July 23.
- 83, 84, 85. Cliff of Dolomite at the base of the *Stringocephalus* zone on island north of Whiteaves Point, Lake Winnipegosis. July 25.
86. Rockyhill on northend of island west of Whiteaves Point, Lake Winnipegosis. July 29.
87. Large boulder on same island.
- 88, 89, 90. Swampy Crees in camp at Shoal River, Man. July 30.
91. High beach of rounded pebbles at south end of island off Salt Point, Lake Winnipegosis. August 3.
92. Cliff at Point Wilkins, showing sandstone included in the fragmentary limestone. August 6.
93. Inclusion of sandstone in the broken limestone at Point Wilkins, Lake Winnipegosis. August 6.
94. Cliff of limestone rising forty feet above the water just south of Point Wilkins. August 6.
95. Cliff of thick bedded limestone opposite the mouth of Steep Rock River, Lake Winnipegosis. August 7.
96. Cliff of limestone four miles east of Steep Rock River, Lake Winnipegosis. August 9.
97. Point Wilkins at the buttress and cave. August 9.
98. Point Wilkins from Small Island. August 9.
99. Point Wilkins, showing disturbed beds of limestone. August 9.
100. Point Wilkins looking westward. August 9.
101. Cliff of dolomite at point three miles north of Red Deer River, Lake Winnipegosis. August 12.
102. Cliff of dolomite at point five miles north of Red Deer River. Lake Winnipegosis. August 12.

103. Cliff of dolomite at south end of Rowan Island, Lake Winnipegosis. August 12.
104. View up Red River Deer, Saskn., from its mouth. August 13.
105. Lower Salt Spring, Red Deer River, Saskn. Looking eastward down the stream. August 13.
106. Cliff of sloping limestone on Red Deer River, Saskn., a short distance above the Lower Salt Springs. August 13.
107. Glaciated surface of limestone at Rowan Island, Lake Winnipegosis. August 14.
108. North shore of Lake Winnipegosis at the Western Mossy Portage. August 16.
109. Cast of large orthoceratite in cliff of Winnipegosan dolomite, Whiteaves' Point, Lake Winnipegosis. August 17.
110. Shoal River House, H. B. Co., looking towards Swan Lake. August 21.
111. Shoal River House, H. B. Co., looking along the shore.
112. Cliff of Manitoban limestone at the east point of Rose Island, Swan Lake, Man. August 22.
113. Glaciated surface of limestone on Two Islands, Swan Lake, Man. August 24.
114. Birch River, Man., looking up stream from two miles above its mouth. August 25.
115. Indian Camp on the north side of Birch River, Man. August 25.
116. Site of the Hudson's Bay Company's old trading post at the Lower Crossing of Swan River, Man. August 29.
117. Swan River, Man., looking down the stream from the site of the old Trading Post. August 29.
118. Rocky hill, south of Swan River, at the north-east end of the trail. August 30.
- 119 and 120. Rounded bosses of Dakota Sandstone on a terrace on the side of Kettle Hill, south of Swan Lake, Man. September 3.
121. Boulder pavement on the south shore of Red Deer Lake. September 12.
122. Site of old Trading Post of Hudson's Bay Company on the south side of Red Deer River, just west of Red Deer Lake. September 14.
123. Red Deer River, Saskn., from same place. September 15.
124. Site of old Trading Post of the North-west Company on the north side of Red Deer River. September 15.
125. Hartmann's Trading Post at Pine Creek, Lake Winnipegosis, Man October 8.
126. Hartmann's Trading Post at Waterhen River, Man. October 13.

1890.

127. Assiniboine River, Man. Below the mouth of Little Boggy Creek. June 19.
130. Site of old Trading Post of the North-west Company (Grant's House) in the bottom of the Assiniboine Valley. June 19.
131. Bottom of Assiniboine Valley, a short distance further down. June 20.
132. Assiniboine River, near Beulah, Man. June 29.
133. Valley of the Assiniboine from the side of the hill below the site of Boss Hill Fort, north of Virden, Man. July 2.
- 134 and 135. Assiniboine River, at bridge north of Griswold, Man. July 4.
- 136 and 137. Lake Clementi, Brandon Hills, Man. July 6.
138. Assiniboine River, near the mouth of Little Souris River, Man., showing cliffs of sand and gravel. July 8.

139. View across the Assiniboine River towards the sand hills, from the site of the old fort above the mouth of Souris River. July 9.
- 140 and 141. Assiniboine River, at the outcrop of Niobrara limestone and shale below the mouth of Cypress Creek. July 13.
- 142 and 143. Old Trading Post of the Hudson's Bay Company at Portage la Prairie, Man. July 15.
144. Steamer "Red River," on Lake Winnipeg. July 24.
145. Old Trading Post of the Hudson's Bay Company near the north end of the Tramway at Grand Rapids, Saskatchewan River, Saskn. July 26.
147. Roche Rouge Point, Saskatchewan River, Saskn. July 27.
148. Island, near the Narrows of Cedar Lake, Saskn. July 31.
149. Rabbit Point, Cedar Lake, Saskn. August 1.
150. North-east side of Fort Island, Cedar Lake, Saskn. August 5.
151. North-west side of Fort Island, Cedar Lake, Saskn. August 5.
- 152 and 153. Cliffs of Niagara limestone on the south-west shore of Cedar Lake, Saskn. August 8.
154. Trading Post of the Hudson's Bay Company at the south end of the Grand Rapids, Saskatchewan River. August 11.
155. Another view of the same. August 14.
156. Saskatchewan River, looking up the stream from Grand Rapids Post towards Potato Island and the foot of the Grand Rapids. August 14.
157. Camp of Geological Survey party, and detachment of North-west Mounted Police at Grand Rapids. August 14.
158. Grand Rapids, Saskatchewan River. Looking up stream from the lower end of the old portage; showing vertical cliff of Niagara dolomite. August 14.
159. Grand Rapids, Saskatchewan River. Another view from a little higher up the stream.
160. Grand Rapids, Saskatchewan River. Looking down stream from the lower end of the old portage.
161. Grand Rapids, Saskatchewan River. Looking across to vertical cliffs on opposite side of river.
162. Grand Rapids, Saskatchewan River. Looking down the gorge from the head of the rapids.
163. Grand Rapids, Saskatchewan River. Head of the rapids, looking across the stream.

GEOLOGICAL SURVEY OF CANADA.

ANNUAL REPORT, 1889-90. PART F.



H. TOPLEY PHOTO.

COPPER CLIFF MINE, LOOKING WEST.

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GEOLOGICAL SURVEY DEPARTMENT.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

SUDBURY MINING DISTRICT

*To accompany Sheet 130, Series of Geologically coloured
Maps of Ontario.*

BY ROBERT BELL, B.A.Sc., M.D., LL.D.

1888-90.



OTTAWA:

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S
MOST EXCELLENT MAJESTY.

1891.

To DR. A. R. C. SELWYN, C.M.G., F.R.S., ETC.

SIR,—Herewith I beg to hand you my report on the results of the geological and topographical surveys and investigations in the Sudbury mining district, during the past three seasons, with which I had the honour of being entrusted.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL

GEOLOGICAL SURVEY OFFICE,

OTTAWA, 20th March, 1891.

RE PORT
ON THE
SUDSBURY MINING DISTRICT,
BY ROBERT BELL, B.A.Sc., M.D., LL.D.

INTRODUCTION.

The following report is upon the labours of the last three seasons in what may, for convenience, be called the Sudbury mining district. An epitome of what has been accomplished has already been given in the three summary reports of 1888 to 1890, but all the results will now be collated in a more complete form.

I was assisted in both the topographical and geological work by Mr. A. E. Barlow, M.A., of this department. He was occupied more especially in the south-eastern and central parts of the sheet. His topographical surveys are mentioned more particularly further on, and an account of his geological observations is given along with my own. Mr. A. M. Campbell, of Perth, also assisted us during the three seasons this work was in progress. Mr. Wm. Skynner was engaged upon it for portions of 1888 and 1889, and in 1890 we had the services of three young gentlemen as students, namely : Mr. T. L. Walker, M.A., Mr. H. H. Walker, B.A.Sc., and Mr. H. G. Skill. To all of these gentlemen great credit is due for enthusiasm and patient endurance of the hardships and discomforts incidental to this kind of work.

We are indebted for assistance or information in the prosecution of our labours to Mr. D. McTavish and Mr. T. B. Ross, of the Hudson's Bay Company ; to Dr. E. D. Peters, ex-manager of the Canadian Copper Company ; Messrs. O. Emery and D. McLaren, of Wahnapitæ ; T. J. Kennedy, C.E., of Pogamasing ; T. Frood, of Wallace Mine ; J. Stobie and C. W. Jessop, of Sudbury : J. R. Gordon, of Creighton ; F. L. Sperry, late chemist to the Canadian Copper Company ; F. R. W. Daw, manager of the Murray Mine ; J. Ferguson, manager of the Dominion Mine ; A. Merry ; W. Cockburn, of Sturgeon Falls ; A. McCharles, of Whitefish ; H. Ranger, of Mattawa, and others.

Acknowledgment of aid.

Prof. Williams' description of the rocks.

Prof. T. G. Bonney.

List of levels.

List of Lepidoptera by Major H. H. Lyman.

Map.

Area and position of the district.

Surveys here-
tofore made.

Professor George H. Williams, of Johns Hopkins University, has made for us a painstaking microscopical examination of a collection of rock-specimens from the district, and his descriptions, which will be again referred to, form Appendix I of this report. Professor T. G. Bonney, of London, has also kindly supplied me with some petrographical notes on the district.

Appendix II consists of a list compiled by Mr. Barlow, showing the levels, above the sea, at every mile on the main line and also on the Sault Ste. Marie branch of the Canadian Pacific Railway, which come within the limits of the sheet, and of the principal streams at their intersections by the railway line; also of the levels of the larger lakes as determined by the barometer.

Our thanks are once more due to Major H. H. Lyman, of Montreal, who has this winter gratuitously determined a collection of Lepidoptera which I had made in the country north of Lake Huron. He finds it to contain fifty-four (54) species, represented by a considerable number of specimens from many localities in the above district. Major Lyman was assisted by Mr. Wm. H. Edwards, Professor J. B. Smith and Rev. Geo. D. Hulst. The list of species forms Appendix III of this report.

A map has been compiled and drawn by Messrs. Scott Barlow, A. E. Barlow and L. N. Richard on a scale of two miles to the inch, and reduced under the supervision of Mr. Scott Barlow, for publication, on a scale of four miles to the inch, showing the topography and geology of the area investigated. As the geological and most of the topographical features of the district have been as yet unknown, this map, which will accompany the present report, will be essential for reference in connection with the descriptions herein given. It constitutes sheet number 130 of the general Ontario series and the district which it embraces measures seventy-two miles in length from east to west and forty-eight miles in breadth from north to south. It thus includes an area of 3,456 square miles, or 2,211,840 acres. The town of Sudbury Junction lies ten miles south-east of the centre of the above rectangle. The main line of the Canadian Pacific Railway runs north-west across the sheet, emerging near its north-west corner, not far from Pogamasing Lake, and the Sault Ste. Marie branch, running south-westward from Sudbury Junction, emerges at the south-west corner in the township of Hallam. Sturgeon River crosses the north-east corner, and the West Bay of Lake Nipissing enters the south-east corner. These geographical positions will enable the reader to form a better idea of the size and location of the above district.

Nearly half the included lands, or 1,530 square miles, have been laid off into townships, which again have been subdivided into concessions

and lots. These townships are of the more recent form adopted by the Crown Lands Department of Ontario and measure six miles square, each one comprising six concessions, running east and west, and each concession twelve lots. The townships themselves are arranged like squares on a checker-board, and as their subdivisions are all alike, both the concessions and the lots carry the same numbers from one to another throughout. All the township boundaries, or town-lines, the concession lines and every second lot line, called side-lines, are cut out through the woods, and posts, marked with the numbers of the concessions and lots, are planted at the intersections of the above lines. Each lot, therefore, contains half a square mile or 320 acres. For the sake of greater clearness the numbers of the concessions are always designated by Roman numerals and those of the lots by ordinary figures, both on the map and in this report. In tracing out the rocks, we found the surveyors' lines and posts of much service in fixing our positions.

The railway track afforded us a means of getting into the district and a sort of basis for operations, but scarcely any common roads or even trails existed* and there are fewer canoe-routes than usual in the Laurentian and Huronian regions of Canada, so that it became necessary to examine a large portion of the area by forcing our way through the bush, which, in most of the district, is unusually difficult to traverse. In some sections the surveyors' lines made it easier to penetrate the thick woods, but as these are cut out merely for sighting, the felled trees and brush and the new growths are as apt to encumber the ground and impede one's progress as the standing forest and underbrush.

The average general elevation of the district is probably between 800 and 1,000 feet above the sea.† The district, taken as a whole, may be described as hilly and rocky, although a tolerably level tract, six miles wide, extends from near Wahnapitæ Lake south-westward to Vermilion Lake. Parts of this tract are covered by a light coloured fine clayey sand, free from boulders. Some of this land along the line of the railway between Chelmsford and Onaping is being cultivated; but rocky ridges and boulder-covered slopes, alternating with swamps and small lakes, are the rule over the greater portion of the area. In most parts the boulders are not only thickly scattered over the uneven rocky surface, but are often piled on top of one another without any finer materials between them. The trees which originally grew between and even on top of the boulders have generally been killed by forest fires and their trunks have fallen over them in every direction. A second

Want of facilities for geological field-work.

General character of the country.

Difficulties of exploration.

* A colonization road has lately been constructed from Sudbury for eleven miles northwest and three and a half south-west.

† A list of levels throughout the district is given as an appendix.

growth thicket of small prickly spruces entangled with tough young birches has sprung up among the boulders and resists the explorers' progress like a continuous hedge. This, together with the uncertain footing, due to the boulders and the network of prostrate trunks, renders it very difficult to make one's way through these obstructions. Indeed, it sometimes became impossible to do so until we had first chopped a passage through them. Last summer and autumn were unusually rainy, so that whenever we got clear of the boulders and hummocky rocks we were obliged to wade in the water.

SURVEYS.

Proudfoot's lines.

In addition to the railway and the township surveys, a straight line had been run, in 1888, by Mr. H. B. Proudfoot, P.L.S., for the Crown Lands Department, due north in continuation of the east town-line of Lumsden, to a point four miles and a-half north of the northern boundary of our sheet, and from this point another straight line was run by the same gentleman due west to beyond Lake Pogamasing. Although this latter line was outside of the area with which we were more immediately concerned, still it was of service for tying on our exploratory and micrometer surveys. Topographical surveys had also been made by the late Mr. Alexander Murray, of the Geological Survey, of Wahnapitæ River and Lake and Sturgeon River, Lake Panache and the canoe-route thence to Wahnapitæ Lake; also of the curving chain of lakes from the latter to Sturgeon River. Mr. Murray had also surveyed the Spanish River from the mouth to a point a few miles above the Great Bend, but this survey had been covered by the township surveys in that quarter. Many topographical features still remained unsurveyed within the area of the present sheet, and these have now been surveyed and located by Mr. Barlow and myself. Mr. Barlow's topographical work was mainly in the south-eastern part of the sheet, and comprised the West Bay of Lake Nipissing (a re-survey), Panache Lake (a re-survey), the southern branch of Veuve River, Aigin-a-wassing, Elbow and Red Deer Lakes, two western branches of Wahnapitæ River, Ramsay Lake (a re-survey), Vermilion River from Larchwood for eighteen miles upward, in a straight line, and a number of smaller lakes. My own instrumental surveys embraced the Spanish River, from near Spanish Forks to the township of Hyman, Pogamasing Lake, the west shore of Wahnapitæ Lake (a re-survey), the route thence to Vermilion River, and the latter river from the point reached by Mr. Barlow, as far as Proudfoot's east and west line. I also made track-surveys of the route from Bannerman Lake to Onaping Lake, of the latter lake (thirty miles long), Onaping River, the Upper Wahnapitæ

Surveys by
Bell and
Barlow.

River, Koo-ka-gaming Lake and a number of smaller lakes and rivers. In 1875, while exploring this part of the country geologically, I had improved upon a track-survey of the chain of lakes from Lake Wahnapitæ northward by way of Lakes Mattagamashing and Chini-goo-nichi, and in 1888 I carried my track-surveys north-eastward to the Montreal River. In addition to the foregoing, explorations were made of numerous smaller lakes and streams within the sheet. Some of these were performed by the other assistants or students who have been named, and an exploration of the chain of lakes southward of Pogama-sing Lake was made by the late Mr. W. E. Francklyn, who was a member of my party in 1889.

In the topographical and geological descriptions which follow, all distances are understood to be given in straight lines and all bearings refer to the magnetic meridian, unless otherwise stated. The average variation in the district, as stated on the township plans, is about 6° W. in the eastern part of the sheet and 3° W. in the western part. In our geological examinations along the railway tracks, the positions were fixed by the mile-boards, which, on the main line, are numbered from Montreal and on the Sault Ste. Marie branch from Sudbury Junction. All existing geographical names were adopted for the map and this report. In some cases the expressive Indian names which had been in use from time immemorial had been replaced by others on the surveyors' township plans. In such instances, while accepting the latter, we have also restored the aboriginal designations upon our map. But it was found that many features made known by our explorations and surveys, to which frequent reference required to be made, had no names whatever, and to these, for convenience of reference, we were obliged to give some distinguishing appellation.

Geographical names.

GEOLOGY.

In connection with the geological descriptions, passing references will be made to the surface geology and the occurrence of ores or other economic minerals, but the principal part of the information as to these subjects will be reserved for fuller descriptions by themselves in another part of the report.

Lithologically speaking, there is a great variety of rocks in the district and many of them are of much interest in connection with a study of the problems of metamorphism, etc. A collection of fifty specimens above referred to, mostly from within the district, was submitted for microscopical examination to Professor George H. Williams, of Johns Hopkins University, the well known lithologist. A few specimens, however, were included in this collection from places outside of the district on account of their bearing on its geology, and it was thought that a study of them would be of advantage in this connection. We report.

Lithological names.
Prof. G. H. Williams'

are indebted to Professor Williams for the great pains he bestowed on this task. His report forms Appendix I. Mr. Walter Ferrier of this Survey has examined microscopically some thin slices of rocks from the Sudbury district and has given us the benefit of his studies.

Field names
for rocks.

In the field, however, it is impossible to make the precise distinctions which may be established by subsequent microscopical study. The most appropriate field names have, therefore, to be adopted, and in the present report these are often adhered to for brevity of description. For example, it is frequently difficult to distinguish between such rocks as diorites, diabases, basalts, gabbros, etc., nor, indeed, is it always of practical importance to do so. But when we were tolerably certain, from the macroscopic characters, of the variety we were dealing with, we called it, in our notes, by its proper distinctive name; but where there was room for doubt, we adopted the general term greenstone. On this point Professor Williams, in his report on The Greenstone-Schist Areas of the Menominee and Marquette Regions of Michigan,* says: "I feel no especial apology is needed for the constant use throughout this paper of the term 'greenstone.' An opinion prevails that this word is antiquated and not consistent with the scientific accuracy now obtainable. The very indefiniteness of this designation, however, constitutes its chief value. It is essentially a field term, and as it is not only desirable, but absolutely necessary to employ. It is often impossible to state with certainty in the field whether a given basic massive rock is a gabbro, a diabase or a diorite; indeed, where such masses have undergone extensive metamorphism, as in the regions here studied, even the most careful microscopical and chemical investigation may prove inadequate to disclose what was the original form."

Similarly it is impossible to give at sight the refined lithological name for every variety of rock of the granitoid class, but the best term for all practical purposes had to be adopted in each case in the field. Granitoid rocks, consisting of quartz, orthoclase, plagioclase, hornblende or chlorite and sometimes a little mica, together with a variety of accessory minerals, were among the commonest we had to deal with. The quartz was generally one of the most abundant constituents, and the rock would then be called a granite, but sometimes it was in small quantity, or it might be scarcely apparent without the aid of the microscope, when it was termed syenite, or if fine grained micropegmatite. Again, the term greywacke may be applied to certain varieties of arkose, argillaceous or felspathic sandstone, volcanic mud or ash, granitic debris, etc. It is often puzzling to discriminate between the numerous varieties of green schists and other crystalline rocks, so

* Bulletin of the United States' Geological Survey, No. 62, 1890.

that in the field, hard and fast lines cannot be drawn in reference to names for many of the rocks which we had to deal with in this district,

The term "massive" was employed in our field-books and it will Massive rocks. also be used in this report, not only in connection with crystalline rocks, such as greenstone and granite, but also in regard to any solid or heavily bedded rock in which the stratification was faint or which showed neither cleavage nor lines of division along the bedding.

The rocks of the district represented by the map may, for the present, be divided into three groups, in the following ascending order : Divisions of the rocks.
(1.) A gneiss and hornblende-granite series—Laurentian. (2.) A series comprising quartzites, massive greywackes, often holding rounded and angular fragments, slaty greywackes with and without included fragments, drab and dark grey argillites and clay-slates, dioritic, hornblendic, sericitic, felsitic, micaceous and other schists, and occasionally dolomites, together with large included masses or areas of pyritiferous greenstones. This group constitutes the ordinary Huronian of the district. (3.) A division consisting of a thick band of dark-coloured siliceous volcanic breccia and black slate (generally coarse), overlaid by drab and dark grey argillaceous and nearly black gritty sandstones and shaly bands. The breccia is underlaid in places by quartzite conglomerate. (4.) In addition to these, dykes of diabase and gabbro cut through all the foregoing and are therefore newer than any of them, although they may not belong to a later geological period. The geographical distribution of these different divisions, their characters, their relations to each other and various facts in regard to them will be given further on.

The rectangle covered by the sheet is traversed from south-west to north-east by a belt of Huronian rocks of the above character (2), flanked on the south-east side by gneiss, and on the north-west by a mixture of gneiss and hornblende-granite. The gneiss of the south-east corner of the sheet is of the characteristic Laurentian type, and in the northern and north-western parts there is a good deal of similar rock, but associated with it and bordering the Huronian belt on its north-west side, there is a large development of reddish hornblende-granite and quartz-syenite, which are not always characteristic of the Laurentian system. But these rocks pass into the gneisses and are so mingled with them on both a large and small scale that it becomes impossible to make a separation, and we have been obliged to indicate them all by one colour on the map.

In the central part of the sheet there is a distinct basin of less altered rocks, being the third division in the above classification, which runs from the township of Trill north-eastward near the South Bay of Lake Wahnapitæ, a distance of thirty-six miles with a breadth of A distinct geological basin.

eight miles in its central portion. These are, perhaps, unconformable to the older Huronian rocks on which they rest, and may be upper Huronian or possibly lower Cambrian. As will be seen by the map, this well-defined basin constitutes an important feature in the geology of the district.

A tongue of gneiss and granite.

To the south-east of it, or in the middle of the belt of older Huronian rocks, a tongue of gneiss and hornblende-granite runs parallel with this trough, a slightly greater distance each way, or a total length of thirty-nine miles, with a breadth of two to three miles. For the greater part of this distance it is separated from the newer basin by a belt of quartzites, greywackes, felsitic and hornblendic schists. It is joined by a narrow neck, in the township of Trill, to the great body of hornblende-granite to the north-west. On the south-east side of this tongue, and almost separated from it by a band of diabase, is a second and parallel belt of similar gneiss and hornblende-granite extending from the township of Denison into Blezard, a distance of eighteen miles, with a breadth of a mile and a-half. As a rule, the gneisses and hornblende-granites of both these belts are finer grained or less thoroughly crystalline and more darkly coloured than those of the great area lying to the north-west of them. In addition to these two almost detached belts of gneissic and granitic rocks, there is a small isolated inlier of red hornblende-granite on the west side of Outlet Bay, Lake Wahnapitæ, and one of gneiss in the fourth concession of Denison.

Part of the great Huronian belt.

Our second or Huronian division of this district forms part of the great belt of these rocks extending from Lakes Superior and Huron nearly to Lake Mistassini. In the central part of the sheet it is very much contracted, being only from ten to twelve miles wide, including the two inlying belts of gneiss and hornblende-granite, but its geographical breadth increases rapidly both to the south-west and north-east. Its north-west boundary or line of contact with the great hornblende-granite area to the northward, in going north-east, crosses Spanish River in the south-western part of the sheet, four miles above the great south-western bend of this stream in the township of Shakespeare, and after throwing off, in the township of Trill, the long tongue already described it continues north-eastward to the west shore of Lake Wahnapitæ, having the basin of newer rocks(3) on its south-eastern side nearly the whole way. From the west side of Lake Wahnapitæ, the boundary turns north-west, crosses the Vermilion River and then both of Proudfoot's lines a short distance west of their point of intersection. The Laurentian area thus forms a promontory, the eastern extremity of which touches Lake Wahnapitæ. Southward of this are the eastern extremities of the basin of newer rocks and the Laurentian tongue just

Its N.-W. boundary.

referred to. Around these three, as a whole, the rocks of the second division sweep with eastward curves, in an anticlinal form, which become more and more divergent and the strata more nearly horizontal as we approach Sturgeon River at the eastern limit of the sheet. It will be seen by the map that the principal topographical features in this section, including Sturgeon River itself, all curve parallel with the trend of the rocks.

Quartzites are the predominating rocks in the Huronian belt from the south-west corner of the sheet eastward to the township of Broder, but they are interstratified with a considerable proportion of greywacke and include a number of the greenstone areas. Around Lake Panache they are associated with dolomites and in the township of Denison with schists, gneiss, diorite, breccia, agglomerate, etc., which will be described further on. Between Lake Panache and the shore of Lake Huron and thence westward to the mouth of Spanish River, including the La Cloche Mountains, the quartzites are very largely developed. The bedding is either nearly vertical or stands at high angles. The more massive or durable wide bands form high east and west ridges, on the steep slopes of which the exposures of white marble-like rock form a striking contrast to the dark green of the coniferous trees. The straight intervening valleys are occupied by lakes, swamps or marshes and streams. The highest parts of the La Cloche Mountains rise to elevations above Lake Huron varying from 755 feet north of Great Cloche Island to 1,180 feet at eight miles north of Collins Inlet. The great quartzite belts which form these mountains appear to double round in the space between Lake Panache and Lake Huron and to be repeated in the high ridges forming the backbones of the long points which jut out south-westward towards Manitowaning Bay. Lake Panache discharges into Lake Huron through a series of narrow east and west lakes lying at successively lower levels and supplied by the short rapid streams or waterfalls that break, at right angles, through the lowest gaps in the quartzite ridges which hold up the water of each one above the level of the next below, the whole chain being called Whitefish River.

Impure magnesian limestones are found at several places along the northern side of Lake Panache. They are generally fine grained and semi-crystalline, of light greyish colours and always contain a large proportion of silica, in the form of grains and threads or strings. The purer of two specimens from the north shore of this lake, analyzed by Dr. T. S. Hunt, gave 55·10 per cent. of carbonate of lime and 6·5 per cent. of carbonate of magnesia, the balance being insoluble matter. The exposures of limestone on this lake do not all appear to belong to one band; indeed, they may constitute a number of great masses wholly or partly formed by a process of segregation or concretion and

Strata run in
sweeping
curves.

Quartzites
predominate.

La Cloche
mountains.

Lake Panache
to Lake
Huron.

Magnesian
limestones.

Dolomite on
Wahnapiṭæ
River.

may be unconnected with each other. At one part of the shore, where the limestone is well exposed, Mr. Murray estimated its thickness to be 150 feet. A band of impure light greenish grey dolomite, weathering brown, crosses the Wahnapiṭæ River at Island Portage, about three miles below the outlet of the lake. The rocks are here nearly vertical, but undulate a good deal, and I estimated this band to have a thickness of at least 300 feet.* The rocks around Lake Panache and thence by the canoe-route to Lake Wahnapiṭæ are described by Mr. Murray in the Geological Survey Report for 1853-56, pages 178-190.

Contracted
part of Huron-
ian belt.

Wahnapiṭæ
River.

Huronian
rocks on
Wahnapiṭæ
River.

Supposed
fault.

Disturbed
strata.

In the central or contracted part of the Huronian belt the grey-wackes constitute a large proportion of the whole, and they include a number of areas of greenstone, ranging from a few chains up to one nearly eleven miles in length. The Wahnapiṭæ River, for the first nine miles below the lake of the same name, runs nearly south, crossing the Huronian rocks diagonally and it then meets the Laurentian gneiss and is deflected south-west for eight miles along the boundary between these systems, after which, for the next three miles, it gradually enters upon the older rocks and then turns due south and follows that course till it falls in the rocky delta of the French River.

The rocks which it traverses in the upper nine miles referred to, consist of thinly bedded and more or less felsitic quartzites which have evidently been affected by pressure and shearing and generally show a fluted, striated or ligniform appearance on the bed-planes. They are mostly light grey and fine grained. The strike is north-eastward and the angles of inclination are always high. They are sometimes interstratified by slatey bands.

The line of junction between the Laurentian and Huronian systems runs unusually straight, in a nearly north-eastward course from the township of Broder to beyond the Wahnapiṭæ. It is not improbable that a considerable fault coincides with this section of the common boundary between the two series, as the strike of the adjacent Huronian rocks is not always parallel to the course of the dividing line. An example of this may be seen where the Canadian Pacific Railway crosses the river, the line between the two sets of rocks being here in the bed of the stream. If the course of this supposed fault be continued north-eastward, from a point where the boundary turns more to the east, it would cross the outlet of Wash-ki-gamog Lake where the Huronian strata are greatly disturbed and the clay-slates altered in character, as was first noticed by Mr. Murray in 1856.† The only

* Geological Survey Report for 1875-76, page 296.

† Geological Survey Report for 1853-56, page 174.

other rocks observed on or near this part of the Wahnapitæ were two exposures of greenstone and the band of dolomite mentioned above.

Quartzites are the prevailing rocks on the south side of Lake Wahnapitæ and on most of the adjacent islands and they are also largely developed along the valley of the upper Wahnapitæ River to beyond the north limit of the sheet. They are fine grained and mostly massive along both sides of this part of the river. The strike is everywhere north-westward and the inclination at high angles; but in some places the stratification is very obscure. Greywackes and volcanic ash-beds occur between this part of the stream and Vermilion River and will be described in connection with the geology of the latter.

At the west side of Lake Wahnapitæ, where the Huronian strata come into contact with the Laurentian syenites or granites and gneisses, there is evidence of great disturbance and crushing, the rocks of the two series being much broken up and intermixed along the junction. This is what might have been expected where a point of the older and more solid and resisting set extends so far into the midst of the other, which almost everywhere bears evidence of having sustained great lateral pressure. Specimens 1 to 4 in Professor Williams descriptive list in the appendix are from the largest island in the mouth of West Bay, which lies on the borders of the two systems.

In 1875 I examined North River or the chain of lakes with falls North River. and rapids between them, which stretches northward from the south end of Lake Mattagamashing to the edge of the sheet, and found only light coloured quartzites in that part of the route*. Since that time we have explored the country between this canoe-route and the Upper Wahnapitæ River and found the rocks to consist of quartzites also, Upper Wah-napitæ River except a little argillite south-east of Sam Martin's Lake, a ridge of diorite, running north-west from the head of Boucher Lake, an area of diorite between Mattagamassing Lake and Portage Bay and the high ridge of the same rock mentioned by Mr. Murray as occurring between this bay and the main body of Lake Wahnapitæ.

On either side of a curving chain of lakes from Portage Bay to East of Lake Wahnapitæ. the eastern edge of the sheet, drab-coloured argillites and clay-slates are the prevailing rocks. In the central part of Mattagamassing Lake they pass into a somewhat slatey greywacke with pebbles of granite, or syenite, white quartz and a few of red jasper, usually sparingly scattered through it, constituting what Mr. Murray described as slate-conglomerate.

On the south-east side of Portage Bay and thence north-eastward along Lake Mattagamassing to where it turns east, slate—or greywacke—Slate-conglomerate.

* Geological Survey Report for 1875-76, page 297.

conglomerate, is the prevailing rock ; but from thence to Lake Maskinongéwagaming and in the country between these lakes it is bluish green and drab clay-slate with distinct cleavage. Drab-coloured grey-wacke-conglomerate is largely developed on the west side of Wash-ki-gamog Lake and dark greenish argillite on the east side, while green, red and grey quartzites are associated with these rocks around the southern part of this lake. Clay-slates and slate-conglomerates are Diorite masses found around Murray Lake and thence to Sturgeon River. In addition to the masses of diorite at the southern extremity and near the meeting of the two arms of Lake Mattagamashing, other comparatively small areas of the same rock occur on the western sides of both Lower Mattagamashing and Maskinongéwagaming Lakes, at the south end of Wash-ki-gamog and at the outlet of Murray Lake, and again in the fork of the Maskinongé and Sturgeon Rivers.

Angles of dip. Along the east shore of Lake Wahnapitæ and the north-western part of Lake Mattagamashing, the general eastward inclination of the strata is at tolerably high angles, but elsewhere, in the north-eastern corner of the sheet, the dips are comparatively low, ranging mostly from 10° to 30° , except at the south end of Lake Wash-ki-gamog, where there is much local disturbance with high dips. Indeed, the quartzites which make their appearance here may be brought up in connection with the continuation of the fault, which, as above stated, is supposed to run along the straight part of the Laurentian and Huronian boundary.

A gentle anticlinal.

As Mr. Murray pointed out,* a gentle anticlinal seems to run northward up the basin of Lake Maskinongéwagaming, where the clay-slates are about horizontal and on either side dip to the east and the west at low angles.

Koo-ka-gaming Lake.

Massive dark grey or drab argillite is the principal rock all around Koo-ka-gaming Lake. On the west side of the narrows, near the north end, there is a thick bed of grey quartzite, in the argillite, dipping due east at an angle of 10° . Dark crystalline diorite forms a bluff on the east side at the north end of these narrows, and this rock is found on two islands off their south end, also on a point on the east side of the lake near its south end, and on some of the islands to the north and the south of this point. Around Edith Lake, which lies a short distance north of Mattagamashing Lake, the rocks are all drab-coloured argillites, lying nearly horizontally. Towards the northern part of the lake they become very silicious.

Edith Lake.

Edith Lake has an elevation of more than 100 feet above Mattagamassing Lake, and from the mouth of the brook discharging the former,

Straight valley.

* Geological Survey Report, 1853-56, page 174.

a well marked valley, with high slopes on either side and paved along the bottom with naked boulders and cobble-stones, runs north-north-eastward in a very straight course for the junction of the Obabika River with the Sturgeon. Where the latter strikes the northern boundary of the Laurentian gneiss, two miles below the junction of the Maskinongé, it is deflected eastward at a right angle from its former course and then gradually enters the gneissic area. The details of the geology of the shores of Lake Wahnapitæ and of the route from Portage Bay on its east side to Sturgeon River, are so fully given in Mr. Murray's Report for 1856 that it will be unnecessary to repeat them here. (See Geological Survey Report for 1853-56, pages 171-179.)

Sturgeon
River.

Murray's
description.

GENERAL DESCRIPTION OF VERMILION RIVER.

Vermilion River rises in Ni-nip-ska-gaming Lake, a long narrow sheet of water lying about three miles east of Onaping Lake and running north and south or parallel to it. It discharges northward, but the outlet soon turns eastward, and then south-eastward, and holds this direction all the way to Onwatin Lake, about three miles north of the township of Garson. In this part of its course it cuts off the angle formed by Proudfoot's east-and-west and north-and-south lines, the post marking their intersection being about a mile east of the first intersection and two miles north of the second. My instrumental survey extended up to the east and-west intersection, or three miles beyond the northern edge of the sheet and our explorations reached a point six miles still further north. Below Ni-nip-ska-gaming Lake the river passes through Pi-mitchi-wanga, O-mitchi-wanga and Tonadus Lakes.

Source of
Vermilion
River.

Extent of
survey.

From Proudfoot's east-and-west line all the way to Onwatin Lake, a distance of twenty-two miles in a straight line, the river passes through a succession of narrow lakes connected by stretches of rapid river flowing in rocky defiles and having usually one or two and sometimes more falls with portages in each stretch, so that the general descent must have a considerable grade. Previous to the present survey these lakes had no names and, for the sake of convenience of description, we were obliged to give them those which appear upon the map. The principal tributaries of this part of the river coming within the limits of the sheet are a brook from the east at its northern edge and Ka-wa-wa-ski-gama River, a large branch from the west which falls into Fraser Lake.

Character of
river.

Names.

Tributaries.

Stratified Huronian rocks extend down from the intersection of the river with Proudfoot's east-and-west line to the junction of Black Ash Brook, from the east side, a distance of eleven miles in a straight line, the

General
character
of the rocks.

course of the river being about south-east. Here the stream enters upon an area of hornblende-granite, micropegmatite and gneiss, and its course becomes about south for a distance of nearly eight miles or to the head of Bass Lake, where it emerges upon the volcanic breccia. Its general course over the latter rock is southward to Onwatin Lake, but it makes a large bend to the eastward at Marshy Lake, from which a canoe-route goes north-eastward to the West Bay of Wahnapitæ Lake.

Change in character of the river.

At Onwatin Lake an entire change takes place in both the character and the course of the river. So great is this change that the Indians regard Onwatin (Smooth or Calm) Lake as a river-head from which the stream below derives its name; Onwatin (not Vermilion) River being its Indian designation. It may here be remarked that, as a rule, all over the vast Archaean country inhabited by the Outchipwai Indians, most of the rivers bear the same names as the principal lakes, which in each case are regarded as their source. From Onwatin Lake the river flows with a gentle current, as a rule, all the way to Vermilion lake, in a general west-south-westerly direction, slightly bowed to the north-west, the distance in a straight line being twenty-seven miles; but its channel is so exceedingly tortuous that the actual length of the stream is about three times as great. A fall of about fifty feet occurs at Larchwood, where the Canadian Pacific Railway crosses the river, but besides this there are only a few small rapids, although the river is frequently blocked by great jams of driftwood, each of which renders a portage necessary.

Very tortuous stream.

Relation of rivers to geological basin.

Level country devoid of lakes.

Streams from the north.

Throughout the above section the river flows entirely upon the same rock-formation. At Onwatin Lake, it enters upon the north side of the elongated basin of unaltered argillaceous sandstones and shales, and follows the gentle sweep of their strike all the way to Vermilion Lake, the two lakes lying in corresponding positions nearly at the geographical extremities of this member of the series. In Vermilion Lake the course of the river doubles round and now flows east-north-eastward to the north-west corner of Creighton. The general upward bearing of Whitson Creek coming from the opposite direction is in continuation of this course as far as the north-west corner of Garson, the two streams almost completely surrounding the central part of the geological basin just referred to. The area thus included is tolerably level and is singularly devoid of streams or lakes, thus contrasting with the country outside of this basin. As will be seen by the map, the higher granitic country to the north sends down numerous streams which all join the above section of the Vermilion at right angles. Those between Onwatin Lake and the junction of the Onaping before falling into the Vermilion unite to form the three streams called Pa-wa-tik (Rapid), Sagi-tchi-wai-a-gama (Swiftmouth), and Ping-wi-i-min-kan-

i-wi (Sand Cherry) Rivers, while the Vermilion itself above Onwatin Lake and also the Onaping have similar physiographical characters and belong to the same class.

From the above-mentioned point in the township of Creighton, where Whitson Creek joins the Vermilion, the general course of the latter turns at right angles and flows due south transverse to the strike of the gneisses and diorites as well as of the Huronian quartzites and schists, as far as McCharles Lake*, where it crosses the line of the Canadian Pacific Railway. Between Vermilion and McCharles lakes the river is interrupted by seven falls and rapids, requiring portages to be made in order to pass them.

River crosses
the strike.

Seven port-
ages.

From McCharles Lake the general course of the stream is west-south-west to its junction with the Spanish River at the west town-line of Foster, the distance being twenty-one miles. In this section it flows altogether upon the greywackes, quartzites, felsites, &c., of the lower local division of the Huronian rocks and in the direction of their average strike. Its width varies much, but its principal expansion is Lake Wabagizhik, on the north-west side of which there is a large area of diabase.

w.s.w.
course to the
mouth.

GEOLOGY OF VERMILION RIVER.

Following the above general description of Vermilion River, an account of its geology will now be given. Around the outlet of Omitchiwanga Lake, or four miles in a direct course above Proudfoot's east-and-west line, grey diabase is exposed and on the eastern shore of Tonadus Lake, at two miles and a half above this line the rocks consist of dark greenish-grey argillite. Greywacke of the same colour as the last named rock is exposed on the river at half a mile above the line.

Above Proud-
foot's line.

Proudfoot's line was examined from the corner post for a distance of seven miles west or for six miles from the river, and the country was also explored for a short distance to the eastward of this post. No rock was observed between the river and the corner post, but eastward of the latter the rocks in the first mile consist of dark greenish-grey argillites, quartzose greywackes and greywackes containing hornblende, all striking N.W. and S. E. On the western shore of a good sized lake, a mile and a quarter east of the post, the last mentioned rocks are again exposed, while from its south-western extremity reddish hornblende-granite of medium texture extends to the south-westward.

East of Ver-
million River.

*This lake, which extends for three miles and a half eastward of the Vermilion River in the township of Graham, was formerly called "Vermilion Lake" on the township map, but as this name was preoccupied by the larger lake in the township of Fairbank, another name became necessary and we called it McCharles Lake in honour of Mr. A. McCharles, who resides on its northern shore and is doing much to promote the mining industry.

- West of Vermilion River. As already stated the river intersects the east-and-west line referred to a short distance west of the first mile post. Following this line, the steep ascent on the west side of the river exposes a very dark coloured silicious conglomerate with small white quartz pebbles. Between the second and third mile posts (from the corner) the rocks are massive, coarse grey quartzite and grey quartzose or greywacke-conglomerate, the pebbles of which are mostly of white quartz and grey aplite or binary granite. The last exposure of this rock occurs about a quarter of a mile east of the three-mile post and the first one of Laurentian rock at one-eighth of a mile west of the same post. Between three and five miles and a-half (also from the same post) the rocks consist of very massive but rather fine-grained light pink and grey aplite, with the exception of a streak, twenty or thirty yards in width, of green schist, containing cubes of iron pyrites and running a little east of north. At five miles and a-half a short interval of coarsely crystalline hornblende and felspar rock occurs, beyond which, to the seventh mile, there is a moderately fine-grained quartzose syenite-gneiss and a more coarsely crystalline quartz-felspar rock without foliation. After leaving the valley of the Vermilion River going west, Proudfoot's line passes over almost bare rock, with clumps of small Banksian pines as far as I followed it.
- Greywacke-conglomerate. Quartz-syenite. Gneiss. Below Proudfoot's line. Quartzite conglomerate. Black Ash Brook. Camp Island.
- Below this line the river flows south-eastward till we reach Black Ash Brook and the general strike of the rocks is in the same direction. They consist of quartzites, greywackes, argillites and clay-slates. On the south-west side of Proudfoot's Lake (between the intersections of the two lines of the same name) there is a coarse grey quartzite, so massive that the lines of stratification can only be traced in some parts. The dip is N. E. $< 60^\circ$. At the outlet of this lake or half a mile above the intersection of Proudfoot's north-and-south line, a grey quartzite with small white quartz pebbles dips N. 20° W. $< 65^\circ$. This abnormal dip is, perhaps, due to the proximity of an area of red hornblende-granite to the eastward of it. From this line, for three miles downward, grey or greenish grey and drab clay-slates, some of them suitable for flagging, are the only rocks exposed. The course of the river conforms with the strike, which is generally about S. 35° E. and the inclination is to the north-eastward at an average angle of 60° .
- The river continues in the same general course for six miles more (nine miles in all from the line) to Black Ash Brook, where it passes off the Huronian system. The rocks for these six miles consist of quartzites, alternating with argillites and clay-slates, with some greywackes. An island at the commencement of this section was named Camp Island for the convenience of local description. In this vicinity a dark grey quartzite dips N. 30° W. at a high angle, while a few

chains further down the same rock dips N. 40° E. $< 30^{\circ}$. Close to the latter, and apparently underlying it, there is a massive drab-coloured argillite which shows no stratification.

Campbell Lake, measuring upwards of a mile in each direction, was discovered at two miles and a-half north-east of Camp Island. Campbell Lake.

Between the river and this lake several ridges of greywacke of different shades and textures were crossed, the strike being generally northward, but varying to 10° , 15° and even 20° to the east of north. On the shores of Campbell Lake the rocks consist of, (1) greywacke with patches of quartz pebbles, of all sizes, and silicious inclusions which weather to a sponge-like surface and, (2) silicious volcanic breccia, holding sponge-like quartz fragments and patches. On an exploration from Camp Island in the opposite direction, or south-west from the river, as far as Proudfoot's north-and-south line, the only rock met with was at three-quarters of a mile, and consisted of a fine-grained greywacke, which showed no stratification.

Three-quarters of a mile below Camp Island, massive quartzite appears, and at a quarter of a mile further massive greenish-drab argillite, striking N. 21° W., the dip being vertical. Pot-hole Falls, with a descent of thirty-five feet, occur at a mile and a-quarter below Camp Island. Here a cliff on the south-west side of the river shows sections of ancient pot-holes much larger than the present stream would appear capable of forming. In this vicinity massive greenish-drab argillite, massive ash-grey quartzite and grey silicious conglomerate with pebbles of hornblende-granite occur, striking, respectively, S. 62° W., S. 68° W. and N. 70° W. The bedding of the first and last is on edge, but in the other case the dip is S. 22° E. $< 15^{\circ}$, showing the existence of a fault or other disturbance. Half a mile further down there is another fall, and here the rock is indurated greenish-drab clay-slate, striking due west vertically, while its cleavage, which is also vertical, runs N. 15° W. Ka-ko-zhish Falls, twenty-five feet high, occur a little more than half a mile below the last fall. A dyke of diabase, over 100 feet wide, here runs N. 65° W. and greenish-drab clay-slates, on its north-east side, strike N. 20° W.; but ten chains further down where the river enters Otter Rock Lake, similar slates strike N. 50° W. and dip N. 40° E. $< 80^{\circ}$. On the east side of this lake the rock is fine-grained massive greywacke, while on the north side it is dark bluish clay-slate, striking N. 55° W. $< 90^{\circ}$. A ridge of angular fragments of banded greenish-grey slate crosses this lake. Bluffs of grey quartzite overlook the north-east side of Gibson Lake and a grey quartzite-conglomerate is found at its head. A short distance above the head of this lake there is a portage past a rapid, a quarter of a

Ka-ko-zhish Falls.

Otter Rock Lake.

Gibson Lake.

mile long. At the foot of this rapid, the rock is a massive, rather coarse light grey quartzite, running N. 50° W. $< 90^{\circ}$.

Mowat Lake. Mowat Lake lies two miles and a half east of this point, and in the interval there are two ridges of massive grey quartzite. This lake is two miles long and discharges at its south-east extremity, where the rock is grey quartzite. But on its south-west side, greywacke occurs, passing into dark blue-grey slate and striking S. 65° E. $< 90^{\circ}$. In the hills overlooking this side of the lake, dark coarse slate and grey quartzite are seen striking N. 50° W. $< 90^{\circ}$. A traverse was also made south-west from the foot of the above portage as far as Ka-wa-wa-kash-ki-gama River, three miles distant and the following rocks were noted ; at a quarter of a mile. light grey quartzite, striking north-west : at half a mile, dark grey greywacke without observed bedding ; at one mile and a quarter, dark grey clay-slate, striking north-west ; at two miles, a ridge of grey diabase, running about north and south. The last named river was explored for some distance up and down, but no fixed rock was found in its bed.

First gneiss.

Glossy green schists appears at the mouth of Black Ash Brook and massive pink gneiss on the opposite side of the Vermilion, being the first occurrence of gneiss in descending the stream. Half a mile above the junction of the Ka-wa-wa-kash-ki-gama, reddish gneiss strikes N. 10° to 40° W., and half a mile below it a similar rock occurs with folded lamination. Reddish gneiss, with an occasional band of grey, continues for four miles and a half below the above branch river, the prevailing strike being N. N. E., but in one case it is N. N. W. At the end of this distance the river makes a very sharp elbow to the S. S. W., and falls over a large diabase dyke which runs N. N. E.

Large dyke.

From this dyke down to the head of Bass Lake, a distance of two miles and a half, the rocks consist of rather fine-grained dark reddish-grey hornblende granite. The same rock was found by exploration to extend to a distance of three miles eastward of this part of the river, and from other explorations we know that rather coarser varieties of hornblende-granite, along with gneiss and some diorite, extend to the west side of Lake Wahnapitæ.

Bass Lake.

At the head of Bass Lake the river enters upon the dark volcanic breccia described in a former part of this report, and this rock is exposed in a number of places as far as Onwatin Lake. The strike is S. 35° W., at the above locality, and S. 40° W. half a mile above and again half a mile below Marshy Lake. The breccia is very massive as far as the head of the long rapid just before the river falls into Onwatin Lake, where it becomes coarsely slaty with a "lumpy" cleavage and strikes S. 45° W. At the outlet of Marshy Lake a dyke of rather light grey diabase about 400 feet wide crosses the river and appears to

Ka-wa-wa-kash-ki-gama River.

Great diabase dyke.

run about ten degrees south of west and probably causes the great bend which the river makes in this part.

From Onwatin Lake all the way to Vermilion Lake, as already stated, the river flows with the strike along the north-western side of the basin of grey argillaceous sandstones interstratified with softer beds. From a point three miles and a half, in a straight line, from the inlet of Onwatin Lake as far as the middle of the township of Lumsden, all the numerous southward bends of the stream touch the outcropping edge of the same band of the formation, which, with a southward dip, sweeps round in a gentle northward curve between these points. In this interval the sandstones and the slaty beds are generally dark grey, and the latter are sometimes black. The sandstone is characterized by disseminated grains of transparent quartz and it also holds occasional ovate spots of a different hardness and a lighter colour than the average, measuring from a few inches up to three or four feet in diameter. These weather, on exposed surfaces, into oval and rounded depressions, the larger of which are locally known as "Nanabozhoo's snowshoe tracks." These are well seen on the rock-surfaces at Larchwood where the Canadian Pacific Railway crosses the river and they are again met with at Chelmsford on the opposite side of the synclinal. Below Larchwood the argillaceous sandstones with the oval depressions on weathered surfaces are exposed frequently in the banks of the river for the first half of the distance to Vermilion Lake. The dip is south-east at high angles and the strike very straight, the bedding never being curved or disturbed. In the lower half of the distance nothing but sand is to be seen along the river.

The rock just described under the name of argillaceous sandstone might also be called arkose or greywacke, but for the sake of distinction, these names are reserved for the rocks of the older division in this district, which generally bear more distinct evidence of being made up of the débris of granite or quartz-syenite. They have a great similarity to the dark grey silicious rocks which are scattered so abundantly in the form of boulders around the shores of James' Bay and over the country to the south and west, and which occur *in situ* on Long Island, Eastmain; and they also resemble the dark grey greywacke or felsitic sandstone at the mouth of Churchill River on the west side of Hudson Bay.

The country on the south side of Vermilion Lake is hilly and somewhat rugged, the highest elevations being towards the west end. The rocks of these consist of coarse black schist full of foreign fragments, mostly of quartz-syenite. The cleavage strikes S. 60° W., and dips to the south-eastward at an angle of 55° , but no distinct bedding could be observed. These rocks form part of the black breccia band, else-

Oval depres-
sions in sur-
face of rock.

Below Larch-
wood.

Comparison
with similar
rocks else-
where.

Vermilion
Lake.

Black slate. where described, and contain, as usual, a good deal of iron pyrites. Further east, on the south side of the lake, the rock is a fissile black slate with vertical cleavage, striking parallel to the shore. At the first portage below the lake, which is past a fall on lot 10, concession VI, Creighton, the black slate is full of cubes of iron pyrites. The cleavage is vertical and runs 5° north of west. On this lot, and only a short distance west of the portage, a good sized vein containing galena and iron pyrites cuts across the slate. Other veins in Fairbank and Creighton are being tested for gold.

Mineral-bearing vein.

River turns south.

Huronian rocks.

Levy River.

Rock like "hällefinta."

Hornblende gneiss.

Whitson Creek from the east joins the river at the foot of this fall, and now the general course of the stream turns south and flows across the strike of the rocks as far as McCharles Lake, on the south side of the Sault Ste. Marie branch of the Canadian Pacific Railway. As already stated, the general descent of the river is rapid, and seven portages occur in the interval. On lot 11, concession V of Creighton, about a mile below the first portage, grey quartzite and greywacke occur, striking S. 60° W. Greenish-grey fine grained hornblendic schist is met with on the next lot to the west (No. 12, con. V), and grey quartzite is found in Fairbank, two miles to the westward of this locality. Schist similar to the last occurs half-a mile above the second portage, which is at the north end of lot 1, concession III, Fairbank, about three miles from the first portage. Here the rocks are light and dark grey quartzites, containing much felspar and passing into greywacke. The strike is S. 60° W. Quartzite occurs on the north end of lot 3, concession III, a mile west of this portage, and it was traced thence south-westward for upwards of two miles, when it became flanked on either side by fine-grained gneiss.

Along the north-western margin of the gneiss in the valley of Levy River to the north-eastward of this part of the Vermilion there is a belt of dark greenish-grey and almost black felsitic schist with chlorite and black mica in fine scales covering the cleavage surfaces. This rock corresponds with the "hällefinta" of Norway. It is exposed at Emma and Moore Lakes; also on the section of Levy River between them and for some distance to the northward of it, and again on the islands and points in the northern part of White Water Lake, as well as to the north-west of the boundary of the gneiss at the point where it is crossed by the Canadian Pacific Railway near this lake.

The third portage occurs two miles below the second on the south end of lot 11, con. II, Creighton. Here the rock is all a dark grey hornblende-gneiss striking S. 60° W. At the fourth portage, half a mile further down there is a dark rather coarsely crystalline diorite, much pitted over most of the exposed surfaces. The fifth portage begins about a mile below the fourth, and is a quarter of a mile long.

Here the rock is reddish gneiss, mostly of light shades. Some parts of it, however, are coarse and massive, resembling granite and other parts finer and more darkly coloured than the average. The stratification is not very distinct, but it runs about west-south-west. At the foot of this portage, which is on the south end of lot 11, con. VI, Graham, a greenstone dyke, eleven feet wide, runs N. 73° E. The gneiss continues nearly to the head of the sixth portage on lot 1, con. IV, Denison. At this portage the rock is soft felsitic schist, the cleavage surfaces of which glisten with fine scales of mica. It passes into greywacke, some beds being massive and silicious, approaching quartzite. The strike is N. 55° W. $< 90^{\circ}$. Similar soft grey schist with finely glistening surfaces continues for a mile below the sixth portage. Here the cleavage is almost vertical with a south-westward strike, and the exposed edges are eroded into holes elongated in the direction of the cleavage. Half a mile below this portage the river touches the west town-line of Denison, where a ridge of diorite crosses it and several large quartz veins, with a westerly course, are found at the same locality. A little molybdenite was the only other mineral observed in these veins. Between the town-line of Graham and the crossing of the Canadian Pacific Railway, at the seventh portage, a massive fine-grained bluish-grey greywacke occurs, striking S. 80° W. $< 90^{\circ}$. At the head of the seventh portage the rock is bluish and greenish-grey soft felsitic schist, passing into greywacke, and striking S. 70° W. $< 90^{\circ}$. On the railway line, a short distance west of the river, there is a cutting through dark, and in parts almost black, splintery clay-slate. Following the line, at one-third of a mile west of the river, a massive grey greywacke, with a few beds of dark shale, stands nearly vertically and strikes N. 75° W. Grey greywacke, in beds from three inches to two feet in thickness, striking due west with a southward dip of 85° , continues to Whitefish Station on the north end of lot 1, con. I, Denison.

The geology of the lower part of the river will now be described from the mouth upward to the intersection of the Canadian Pacific Railway. A long rapid occurs just before the Vermilion River joins the Spanish, necessitating a portage of three-quarters of a mile in length. At the lower end of this portage a grey schist, striking S. 45° W., occurs, while just above its upper extremity the rock is a yellow quartzite, striking S. 80° W., and dipping southward at an angle of 60° . In the rapids at the outlet of Lake Wabagizhik and on the first point on the north-west side of the lake a tough splintery grey diabase occurs, with calspar in the joints, but to the north-westward of this rock there is a light grey quartzite which strikes S. 70° W. and comes out upon the river below the rapids just referred to. The promontory near the

Crossing of
the railway.

Lower Ver-
milion River.

Lake Waba-
gizhik.

Large area of diabase.

middle of the north-west side of the lake consists of a light grey quartzite with some beds of greywacke, but the rock of all the rest of the shore as far as the inlet appears to be a grey diabase, which, in some places, is mottled and more coarsely crystalline than the average.

This forms part of a large area of this rock, extending from the northern part of Foster to the VIth concession of Lorne. Nickeliferous pyrrhotite has been found in this rock on lots 1 and 2, con. III, Nairn, and on lot 11, con. V, Lorne.

Lorne.

On the south side of the inlet of Lake Wabagizhik, a bluish-grey silicious argillite dips S. 60° E. $< 10^{\circ}$. Two miles above this lake, or at the centre of lot 8, con. III, Lorne, the river falls 35 feet, nearly perpendicularly, over a dyke of fine-grained greenstone 30 feet wide running about S. 80° W., or parallel to the south side of this part of the river. The rock on the north side of this dyke is silicious greywacke schist, while on the south side it is light grey quartzite. The latter rock occurs at the next fall, half a mile further up.

Lake Ella.
Quartzites.

Dyke.

Lake Ella is connected with the Vermilion River by a short marshy channel in lot 6, con. II of Lorne. This lake is surrounded entirely with quartzites of different characters, excepting at the points and on an island on the south side which form parts of a large dyke of speckled grey diabase running west-south-west. The general strike of the quartzites is nearly east and west. They contain some bands of an arkose character. On the point near the middle of the north-west side of the lake, two masses of greenstone from 50 to 100 feet in diameter are included in the quartzite, and on the next point to the south-west on this shore, a mass of the same rock mixed with fine-grained grey quartzite rests unconformably upon the eroded edges of the quartzite beds, with fragments of the latter of all sizes more or less mixed with greenstone, intervening.

Lorne.

Above Lake Ella a schistose greywacke is found on lot 5, con. III, Lorne. The course of the river, which is straight in this vicinity, is probably determined by a greenstone dyke running S. 36° W. along its south-eastern side. The next upward stretch of the stream is at right angles to the last and lies between two dykes of dark heavy decomposing greenstone, the first of which runs N. 40° W., and the other appears to be quite parallel to it at a distance of a quarter of a mile to the north-east. Light and dark grey and greenish grey quartzites prevail everywhere in this part of Lorne and continue thence into Louise. Between the two dykes just mentioned a grey felsitic quartzite dips S. 30° W. $< 45^{\circ}$.

Louise.

Throughout the township of Louise and thence to the intersection of the Vermilion by the Canadian Pacific Railway, quartzites, generally largely mixed with felsitic material, are the only rocks met with

near the river. The dip is never less than 45° and is usually nearer the perpendicular. The commonest direction of the strike approaches east and west, but it varies greatly, especially in the vicinity of the greenstone area in the southern part of Denison and the northern part of Louise. Deposits of pyrrhotite have been found Pyrrhotite, in connection with this latter rock at eight localities in concessions I and II of Denison and concession VI of Louise. Felsitic quartzites, or greywackes, with some quartzites of a purer kind are found throughout the Whitefish Indian Reserve, with the exception of a few comparatively small areas of greenstone.

GENERAL DESCRIPTION OF SPANISH RIVER.

The Spanish River having been topographically unknown above the township of Hyman, it became necessary to make a micrometer survey of it, between this locality and the northern boundary of the sheet. This was accomplished by going down stream from a point above the intersection of the Canadian Pacific Railway near Spanish Forks, and after reaching the township of Hyman, the geological examination of the river and the country on either side was continued all the way to the junction of Vermilion River.

At Spanish Forks, sixty-four miles by the railway, north-west of Spanish Forks-Sudbury, two large streams, one from the north and the other from the west, unite to form the main Spanish River, which is the largest stream flowing into Lake Huron west of French River. From the Forks, downward, the course of the Spanish is remarkably straight, bearing S. 13° E. for twenty-two miles, or to the north-west corner of the township of Hart. Here it assumes a course of S. 21° W. for six miles, or to The Elbow, where it turns north-west, forming less than a right angle with its former course and then, sweeping round a semi-circle, it gains a point five miles west-south-west of The Elbow, from which it runs S. 15° W. for eighteen miles to the great south-west bend. From the latter, its course is a little north of east for eighteen miles further to the Great (N.E.) Bend in the southern part of Drury. Between the Great Bend and Lake Huron, a distance of forty-four miles, its course is tolerably straight and bears S. 73° W.

The Canadian Pacific Railway crosses the Upper Spanish River three miles above Pogamasing Station, which is nine miles below Spanish Forks. At this station perpendicular cliffs of red hornblende-granite rise to a height of about three hundred feet above the river. Four miles below Pogamasing Station the stream enters a narrow valley with steep bluffs of red hornblende-granite on one side or the other and often on both sides. This character continues, with a few

Crossing of
Canadian
Pacific rail-
way.

short widenings of the valley and a few exceptions in the nature of the rocks forming its slopes, which will be described further on, till we arrive within four miles and a-half of the great south-west bend, where the river emerges upon the Huronian belt.

Rapids.

Between Pogamasing and the great south-west bend there are many rapids in the river, but only five portages, and these all occur in the first three miles below The Elbow. Agnes River, from the north-west, falls in at the fifth portage. The other principal tributaries are Blue Water River from the west, ten miles below Pogamasing, Onaping Creek from the east, three miles further down, Geneva Creek, also from the east, four miles below the last, and the West Branch, eight miles above the great south-west bend. Numerous rapids and falls occur between the last named locality and the Great (N.E.) Bend, but these will all be noticed in the geological description of the river.

Branches.

POGAMASING LAKE AND THE CHAIN OF LAKES TO THE SOUTHWARD OF IT.

Position of
the lake.

Pogamasing Lake, of which a micrometer survey was made, lies parallel with the Spanish River, at an average distance of one mile west of it. The point at which the Canadian Pacific Railway crosses the river is opposite the middle of the lake and the brook which discharges it falls into the river one mile further up. There are three portages, all of about equal length, about half a mile in each case, from the river to the lake, one at each extremity and one at the middle. The lake is ten miles in length and has an average width of three-quarters of a mile. Its surface, by barometric readings, is 77 feet over Spanish River at the intersection of the railway. A post of the Hudson's Bay Company, which has been long established, stands on an island in the centre of the lake, mid-way between its extremities. The rocks on the shores of the lake consist of the prevailing hornblende-granite, which is all red except on an island near the northern extremity, where it is grey, and dykes of diabase, which were observed in three places, all running nearly parallel with its greater length.

Dimensions
of the lake.

Rocks.

Chain of
lakes.

Another chain
of lakes.

A canoe-route, following a chain of lakes with a general southward course, leaves a bay on the west side of Pogamasing Lake, two miles from its southern extremity. The first lake of this chain, four miles and a half long, was named Kennedy Lake in honour of Mr. T. J. Kennedy, C. E., of Pogamasing. From it the Mogo River flows south, and just below the lake is joined by a stream from another chain of lakes, which we also explored, leading from the southern extremity of Pogamasing Lake. After passing through three other lakes, Blue Water Lake, in the new township of Craig, is reached. A rapid and crooked river of the same name leaves the east side of this lake and

discharges its waters into Spanish River, only two miles and a half distant. The rocks along both of the above chains of lakes consist of red hornblende-granite, except at two miles south of the outlet of Kennedy Lake, where a band of green crystalline schist with a south-west strike crosses one of the lakes. Blue Water River, through its whole course, flows upon a band of dioritic and greywacke schists, which form a westward spur of the Straight Lake Huronian outlier, to be more fully described further on.

GEOLOGY OF SPANISH RIVER.

As already stated, Spanish River was surveyed topographically, as well as geologically, from a point a few miles above the crossing of the Canadian Pacific Railway, north of Pogamasing station, to the township of Hyman, where I connected my work with the township survey; and below this the surveys of Mr. Murray and the Crown Lands Department are continuous, so that henceforward it was not necessary to do any more topographical work, and attention was given entirely to the geology. The rocks found along the river and by exploration on either side have been already referred to in the general geological description of the district, but for the sake of convenience of reference and for practical purposes further details of the geology of this stream will now be given. As in other parts of this report the distances stated will be understood to be measured in straight lines, and the bearings will all be by the compass.

From the crossing of the Canadian Pacific Railway downward, the rocks all along the river consist of the prevailing reddish hornblende-granite of the surrounding country, which has a medium texture, until we arrive at a point six miles and a-half from Pogamasing station, or just below the junction of a brook from the east, where a narrow band of distinctly foliated red and grey gneiss crosses the river. Its general dip is south at an angle of 60° . This is in the run of a wider belt of gneiss which crosses the railway one mile to the eastward between mile-boards 491 and 492. The same belt continues to widen to the eastward and on the canoe-route between Bannerman and Onaping Lakes it has a breadth of about three miles.

In the opposite direction, at two miles and a-half west of this occurrence of gneiss on the Spanish River, green schist, striking south-west, with the red hornblende-granite on either side of it, was found on one of the lakes of the chain running northward from Blue Water Lake. In the township of Craig the river enters at right angles upon a spur of the Straight Lake Huronian outlier in the 4th lot of the Vth concession. Blue Water River, from the lake of the same name, two miles and

a-half to the westward in Craig, falls in at the north end of lot 3, concession IV.

Schists and greenstone on east side of the river.

The rocks of this spur are well exposed on the burnt hills on the east side of the river, opposite the mouth of this branch. They consist principally of schistose greywacke, mingled with massive and schistose greenstone. The greenstone occurs both in broken dyke-like forms, running in different directions, and more abundantly as irregular masses of all sizes, which have somewhat rounded borders. In the latter case the greenstone is serrated at the contact, the indentations corresponding with the abutting ends of the alternating hard and soft layers of the greywacke and taking the same direction as the latter, as if they had influenced the greenstone when it was in a soft state. The hard layers in the greywacke consist of fine grained to vitreous quartzite and vary from a fraction of an inch to several inches in thickness. The strike of the schist is N. 75° E. and the dip northward at angles of 70° to 80° . On mining location F, at this locality, a belt of the schistose greywacke, which weathers to a reddish brown colour, is strongly impregnated with pyrrhotite and pyrite, the proportion of these sulphides in some places being sufficient to constitute a self-roasting ore. No analysis of this ore has been made by the chemist of the Survey, but it is reported to contain a promising quantity of nickel.

Sulphides.

Westward continuation.

This spur of Huronian rocks was traced westward up the whole length of Blue Water River, but not beyond the lake of the same name. However, on the meridian line six miles westward of the west town-line of Craig, the late Mr. Salter, P.L.S., indicated the occurrence of quartzite in the strike of this belt (W. by S.), and it is not improbable that it reappears there and may continue a considerable distance to the westward. Nickeliferous pyrrhotite was discovered and several mining locations were taken up along the Blue Water River subsequent to our survey of Spanish River and the exploration of Blue Water Lake and River by the late Mr. Francklyn, who was a member of the party.

Hornblende-granite.

Greywacke conglomerate.

About a mile and a-half below the Blue Water branch, on lot 2, con. III, the red hornblende-granite is again exposed and continues for four miles along the river with the exception of two exposures of greenstone, one of which is opposite the mouth of Onaping Creek. Greywacke-conglomerate makes its appearance at the above distance and the same rock is again seen half a-mile further down, where it is partly of a massive form and partly schistose. In some parts the rock is full of rounded pebbles of grey quartz-syenite. The strike is S. 35° W. At half a-mile and again at one mile below this the east bank of the river consists of reddish grey hornblende-granite, flanked on the west by soft greenish schist with a little dolomite. Coarse gneissoid schist

with included boulders makes its appearance at an eastward bend Schist holding boulders. of the river a mile and a quarter above The Elbow. It strikes S. 60° W. and dips to the south-eastward at an angle of 70° under the red hornblende-granite.

Just at The Elbow a narrow tongue of grey schistose greywacke extends Rocks at The Elbow. south-eastward into the hornblende-granite, which is here of a greyish colour. A short distance northward of the river, about a mile below The Elbow, there is a bluff of bedded trappian rock resembling diorite, largely mixed with impure dolomite which weathers to a reddish brown colour. Impure dolomite. The bedding is vertical and strikes north-west and south-east. Two of the five portages above mentioned, occur close together at a mile and a-half below The Elbow. At the upper one the prevailing red hornblende-granite holds streaks of green schist and some small veins of a pure looking magnetite. Crystalline greenstone, supposed to belong to Magnetite. a dyke, running north-westward, appears in the bed of the river at the lowermost of these portages. Agnes River falls in from the northward three miles below The Elbow, or immediately opposite the head of the fifth portage. Opposite the foot of this portage there is a dyke of Large dyke. medium grained grey olivine diabase, 240 feet in width, running N. 40° W. Referring to a sample of this rock, Professor G. H. Williams says: "The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite, and biotite. Its diabase or ophitic structure is very typical."—(See fuller description in Appendix I.) The dyke is exposed along the northern margin of the river. Above it rises a bank of boulders, 200 feet high, mixed with some gravel and earth, and forming a conspicuous feature in the valley. From its brink a level gravelly plain, off which the forest has been completely burnt, extends for more than a mile to the north-westward or to a large brook from that quarter which falls into the main stream a mile and a-quarter below Agnes River. A mile below the latter, a brook comes in from the southward and near it, patches of dolomite occur in the red hornblende-granite. Dolomite.

Below these affluents, the Spanish River resumes its southerly course and the reddish hornblende-granite is exposed almost everywhere in the banks for a distance of seventeen miles or to the foot of a straight south-south-easterly stretch two miles long. The West Branch joins the main river two miles above the head of this stretch. Its upward course is about west for the first four miles, above which it turns northward and at one part it is said to come within about six miles of Blue Water Lake. Half-a-mile up this stream a rock consisting of a mixture of green schist and fragments of granite was met with. At the bend four miles up there was found a fine-grained "pinkish to brownish crypto-crystalline banded rock, which might be macroscopically described Granite for 17 miles. Rocks of the West Branch.

as a banded jasper or felsite. The microscope shows that it is a clastic rock consisting mostly of quartz which has been almost wholly recrystallized under the influence of intense pressure and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction that is commonly known as "stretched." (See Salter's notes. Professor Williams' description of specimen 36 in Appendix I.) Salter's first meridian west of his principal one passes through this locality, which corresponds with the north-west corner of township 111, and on the map of this survey quartzite is here indicated. It probably belongs to a band of Huronian rocks which does not extend quite so far east as Spanish River.

A mile below the long straight stretch of the river above referred to, and at a short distance back from the west bank, a bluff was found consisting of a coarsely crystalline blackish and greyish dioritic rock, apparently the side of a dyke. The next rock to be seen is at one mile further on, and consists of white and light yellowish-grey quartzite, dipping S. 40° E. $< 70^{\circ}$. A similar rock, with a bluff of greenstone rising above it, occurs three-quarters of a mile further down and dips N. 50° W. $< 60^{\circ}$. This is a mile and a-half above the south-western bend, below which the river turns at right angles and flows eastward as far as the township of Drury. At the bend itself there is a coarsely crystalline hornblende rock with pitted surfaces. Three miles and a-half below the bend the western town-line of Baldwin crosses the river and in that distance grey quartzites and greywackes are exposed, the strike varying from east to north-east with high angles of dip. A quarter of a mile above the town-line of Baldwin, two masses of greenstone occur in the quartzite, but both appear to be small. From the west town-line of Baldwin for the next two miles eastward, or across lots 12 to 9, inclusive, in concessions V and VI of that township, the rocks consist of grey and greenish-grey greywackes and greywacke-schists, the strike being from N. 60° to 65° E. and the dip nearly vertical.

Quartzites. Hornblende rock. Narrow gorge. Black slate.

In crossing lot 8, concession VI (Baldwin), the river, for a quarter of a mile, contracts to a narrow gorge with a fall of fifteen feet. At the upper end of this gorge the rock is a glossy greywacke schist, running N. 72° E. and at the lower end it is a dark grey clay-slate, running N. 77° E. $< 90^{\circ}$. From lot 7 to lot 5, concession VI, the rock is a fine-grained grey slaty sandstone running N. 72° E. $< 90^{\circ}$. On lot 4 of the same concession, a glossy black slate occurs on the south side opposite an island in the river. A grey glossy ligniform schist striking N. 75° E. $< 90^{\circ}$ is exposed for some distance along the river on lot 2, near the foot of a large island. On lot 1, concession VI, just below this large island, the rocks in the bed of the river consist of fine-grained

pink quartzite, in thin layers, interstratified with rough-surfaced black slate, dipping southward at a high angle, while at a greater elevation there is exposed a heavy band of dark green mica-schist forming the Mica schist. top of a long ridge.

A traverse was made across the township of Hyman along its western town-line and the rocks were found to be as follows: In the southern half of concession I, they are light coloured quartzites and silicious greywackes, while in the northern half a bluish grey slaty greywacke prevails. At one place this contains a band of garnetiferous hornblende biotite "augen" gneiss, which, although a normal rock of that name, evidently forms a part of the quartzite and greywacke series in which it is incorporated. The geological relations and microscopical character of this rock indicate clearly that it has been metamorphosed out of some clastic whose composition has been favourable to the change under the conditions to which it has been subjected. It corresponds with No. 34 of Professor Williams' list in Appendix I (*q. v.*). In the southern part of concession II, a green glistening schist with rounded concretions was met with, followed near the middle of the same concession by a flaggy grey ribboned quartzite. A short distance north of the post between concessions II and III the town-line passes over a hill of light grey quartzite. A greenstone dyke running S. 78° W. was met with in the southern part of concession IV. This was followed at a short distance northward by a hill of slaty quartzite and in the middle of this concession by another hill of a more solid variety of the same rock, running N. 85° W., with a nearly vertical dip. Dark grey silicious greywackes were found in concessions V and VI. Boulders of red hornblende-granite became more abundant before reaching the north-west corner post of Hyman and this rock had been ascertained to occur *in situ* a short distance further north in the course of a traverse which had been made by the writer, eastward from the junction of the West Branch with the main Spanish River.

Genesis of the gneiss.

Quartzites.

Hornblende granite.

Another traverse was made to the south of the Spanish River along the town-line between Baldwin and Nairn, which is a continuation of the line just described. On leaving the river in this direction a ridge of close-grained diorite was found to run south-westward across the middle of concession VI. This is followed by greenish-grey felsitic quartzite or greywacke in the southern part of the same concession. White quartzite was met with across the whole of concession V and into concession IV, and from our examinations elsewhere, quartzites appear to extend to the Spanish River on the opposite side of the Great Bend.

Continuing down Spanish River from the intersection of this town-ship boundary, dark grey diabase is met with at the south-east corner

Rocks of Spanish River.

Glistening schist.

Dyke.

Mica schist with staurolite.

Satiny schist.

Kettle Fall.

Grey schists.

Drury.

Bluish grey schist.

of lot 12, con. I, of Hyman. This exposure is on the north-west side of a mass which appears to be more than a mile in length in a north-easterly direction. At the narrows of the river on the east side of the same lot there is a coarse grey glistening schist and a small quantity of a dark greenstone. Below the narrows on the next lot (11 in the 1st con.) a glossy dark bluish grey schist and a slaty greywacke strike north-east along the flank of the above-mentioned diabase mass. A fine-grained hornblende rock also occurs at this locality. Close by, where the line between lots 10 and 11 intersects the north bank of the river, quartzite occurs, dipping south at an angle of 55° . In the north-west part of lot 9, con. I, a dyke of gabbro, 70 feet wide, crosses the river with a north-west course.

Where the river enters the north-west corner of lot 8, con. I, there is a portage on the north side past a chute with a fall of 15 feet. Here there is an extensive exposure of rather fine-grained silver-grey mica schist, with crystals of staurolite thickly scattered over the cleavage surfaces. In the middle of lot 5, con. II of the same township (Hyman), the river passes through a rocky cañon, or narrows, with grey schist on the northern side and the northern flank of a ridge of fine-grained splintery greenstone running N. 70° E. on the southern. At a rapid in the north half of lot 3 con. II, a bluish-grey satiny schist strikes due north and south, the dip being east at an angle of 45° . This sudden change in the strike is accompanied by an equally sudden turn in the course of the river.

Kettle Fall, with a descent of 20 feet, is on lot 2, con. II (Hyman). The rocks here are grey and satiny schists with a three-feet band of nearly black hornblende schist, all striking N. 76° E. with a southerly dip of 75° . There is a vein of hyaline quartz varying from 3 to 5 feet in thickness at this place, but no other mineral or ore was observed in it. Immediately below Kettle Fall the schists are disturbed, but at a short distance on they have a general dip to the west at an angle of 70° . The next portage is on the right side of the river, on the line between lots 2 and 1, con. I (Hyman) and opposite the west end of an island. Here the rock is a glossy grey finely-arenaceous schist, nearly on edge and striking N. 85° W. A grey glistening schist, standing vertically and striking N. 75° E., occurs at the fall on the south side of the island which has just been referred to. Nickeliferous pyrrhotite has been found in promising quantity on the southern side of a mass of greenstone on the north-east quarter of lot 3, con. I, Hyman.

The Spanish River enters the township of Drury in lot 12, con. I, and a hill of dark-coloured greenstone occurs on the south side of the stream on the same lot. A soft bluish-grey schist striking east-

ward with the course of the river is found on the next lot, 11, con. I, and on the north-east corner of lot 9, con. I, there is glossy green schist Green schist. but without strong cleavage. On the south-east corner of the same lot a rather finely crystalline grey diorite forms a small hill between the river and the Canadian Pacific Railway which passes within a few hundred yards of the stream.

From this lot the river enters the township of Lorne, and from Lorne. the last-mentioned locality a soft greyish-green glistening schist con- Green schist. tinues for a mile down the stream. The next rock met with is in the southern part of lot 11, con. VI of Lorne, and consists of what appears to be a fine grained, greenish-grey silicious felsite with spots and threads of grass-green and pink colours. It does not exhibit any cleavage or bedding. A knob of tough splintery grey diorite occurs on the south end of lot 12, con. VI.

The river now passes into the township of Nairn. At a consider- Nairn. able fall on lot 1, con. V of this township, a dark, almost black, clay- Dark clay- slate is largely exposed. It strikes S. 80° W., and dips southward at slate. an angle of 45° . A small hard black dyke was observed cutting these slates at the foot of the portage, which is on the south-east side of the river.

A distinct moraine, composed of boulders, cobble-stones and gravel, Moraine. and causing a short steep rapid, crosses the river on lot 4, con. V of this township (Nairn). Its general course is about at right angles to that of the glacial striae, which are distinctly seen a short distance Striae. above and below, bearing S. 60° W. On lot 5, con. V, half a mile below the intersection of the moraine, the striae run under an over-hanging rock on the north-west side of the river, grooving both the Ice-grooved wall and roof. A greenstone area, rising in some parts into compara- Greenstone tively high bare hills, extends along the north-west side of the river area. from lot 6, con. V, to lot 11, con. III, a distance of three miles. The glacial groovings are very conspicuously displayed along the south-eastern flank of the greenstone on lot 6, con. IV. On lot 8, con. III, the greenstone is associated with hard green schist, the cleavage of which runs east and west. A grey hydro-mica schist, running south- Schists. west occurs where the Canadian Pacific Railway crosses the river in the centre of lot 11, con. II. In the south-west corner of Nairn the river makes a double or reversed curve like the letter S, in crossing a green-stone area, one portion of which is soft and another hard.

The Spanish River now crosses the north-west corner of the town- Foster. ship of Foster. In the south-west corner of lot 12, con. VI, it falls twenty-five to thirty feet over a strong band of light grey quartzite, Quartzite band. which dips due south at an angle of 70° . The Vermilion River joins the Spanish on lot 12, con. V, just below this fall, and as this brings

us to the edge of the sheet the latter river was not followed any further and I proceeded to examine the Vermilion River. The late Mr. Alexander Murray made a topographical and geological survey of the Spanish River from this point to Lake Huron, as well as to a point above the Great Bend, but he did not work along the Vermilion.

ONAPING LAKE AND RIVER.

Topographical and Geological Description.

Form and position.

Onaping Lake is a long, narrow and straight sheet of water, running about due north and south (ast.) and having an elevation of 1,417 feet above the sea, as determined by barometer. Its southern extremity lies east a few degrees south, twelve miles from Pogamasing station and north a few degrees east, thirteen miles from Cartier station. It has a total length of about twenty-six miles. In the lower six miles or up to the intersection of Proudfoot's east-and-west line, its greatest breadth is a mile and a half, but north of that, it seldom exceeds half a mile and most of it is not over a quarter of a mile. It has two outlets. The smaller one, called Onaping Creek, from its most south-westerly extremity, flows south-westward and falls into Spanish River, thirteen miles below Pogamasing station. The larger is the Onaping River and it leaves the lake four miles and a half east-north-east of the first outlet, at the foot of a bay on the east side.

Two outlets.

Courses of
Onaping
River.

The general course of the Onaping River is south-south-east and it joins the Vermilion one mile above Larchwood on the Canadian Pacific Railway, or twenty-four miles in a straight line from its head. In the first four miles, the course is south-east, then it is due south (ast.) to within four miles of its junction with the Vermilion, where it turns east by north to that stream. Besides numerous small brooks from both sides, it receives four good sized branches from the east, the first at three miles from the outlet, then Michaud's River at six miles, next a brook at one mile above the north townline of Levack and lastly Kinniwbik River, a quarter of a mile north of the southern town-line of the same township. It is interrupted by numerous rapids and falls all along, except in the last four miles. Onaping Lake is most easily reached by canoe from the Canadian Pacific Railway at Bannerman Lake, by ascending Onaping Creek and some small lakes parallel to it, the distance being nine miles.

Branches.

Rapids and falls.

Route.

Dioritic
breccia.

On the railway about a quarter of a mile west of Bannerman Lake there is a confused mixture of schists and dioritic breccia which may be on a line of disturbance extending south-westward from the southern extremity of Onaping Lake. A similar mixture is crossed on the Creek a mile and a half north-east of the railway, beyond which green

schists extend to a short distance north of the northern town-line of Moncrieff. Gneiss is exposed along the route in places for the next three miles northward and then red hornblende-granite and gneiss to Lower Onaping Lake. A spur of the latter rock runs north-east across the lake just named, but Huronian rocks are found on either side of it and they extend to the foot of Onaping Lake. These rocks here form an isolated basin measuring about four miles north-east and south-west by about three miles north-west and south-east. The principal varieties of rocks of this basin or outlier consist of slate-conglomerates with well rounded pebbles and boulders, mostly of binary granite, quartz, quartzite and schists and coarse arenaceous or grey-wacke conglomerates, together with some pale pink quartzites and bluish and greenish-grey felsites, argillites and slates. On an islet one mile south-west of the rapid at the head of the lake there is a brecciated mixture of dark hard slate, diorite and quartzite, while the rest of the islet consists of red felspathic quartzite, half altered into a fine grained binary granite. At various places around this lake, the matrix and finer parts of the greywacke-conglomerates appear to be undergoing alteration, or they show a tendency to pass into a granitoid rock.

Slate-conglomerate.

Other rocks.

Brecciated mixture.

Alteration into granite.

The basin of Onaping Lake appears to owe its origin to denuding agencies which have acted on a north and south dyke or set of dykes of greenstone, cutting the hornblende-granite, which, with some gneissic patches, is the country rock on both sides. The largest of these patches occurs at the wide part of the lake studded with islands, about half way up. Portions of a large dyke, running north-north-eastward, form some of the points and islands along the east shore, near the south end, and parallel to it an unusually long uninterrupted view may be obtained up the lake. Northward of Proudfoot's line sections of dykes and patches of greenstone adhering to the granite walls may be seen here and there all along. In the central part of the lake a narrow bay, on the west side, seven miles long, runs parallel to it, separated by a high tongue of land one mile wide. Towards the north end two narrow lakes, parallel to the main one and four miles long, occupy a position on the west side corresponding with this bay. Onaping Lake is surrounded on all sides by hummocky granite hills, which are comparatively low except on the sides of the narrow bay above mentioned, where they are three or four hundred feet high.

Origin of lake basin.

Large dyke.

Long narrow bay.

Surrounding country.

Gneiss occurs on the shores of the bay out of which Onaping River flows, but from the outlet for a mile and a-half we cross red hornblende-granite, and this is followed by six miles of red and grey gneiss. Below this the rock is again red hornblende-granite to the second concession of Levack. But about the middle of this concession, or a mile and

Geology of
Onaping
River.

Hornblende-
granite.

Distinctly
banded gneiss.

Black por-
phyry.

Great belt of
grey diabase.

Straight
valley.

Windy Lake.

Hornblende
granite.

Volcanic
breccia.

Coarse black
slate.

Dykes along
Onaping
River.

a-quarter above the mouth of the Kinniwabik River, the north-west flank of a range of hills from the north-east comes to the river, the rock of which is very distinctly banded reddish-grey gneiss, which is much contorted and shows numerous small dislocations, but the general strike is S. 65° W. It is cut by irregular straggling dykes of green-stone, full of angular fragments of the wall rock. A dyke only two feet and a-half broad of nearly black porphyry, with widely scattered white crystals and running S. 55° W., cuts both the gneiss and the older dykes. Some coarsely crystalline veins of felspar which occur here hold large crystals of magnetite.

The whole breadth of concession I of Levack, on the course of the river—upwards of a mile—is occupied by a transverse section of a great belt of rather coarsely crystalline grey diabase, which we have traced from the north-east corner of this township, south-westward into Trill, a distance of about eighteen miles. This belt is widest where it is crossed by the Onaping River, and gradually diminishes to a point at either extremity. To the north-eastward its course is marked by a straight valley, down which the lower part of the Kinniwabik River flows, but between the Onaping and Windy Lake it is covered by a great accumulation of sand, gravel and boulder-earth, forming hills in that direction. Windy Lake lies about mid-way on its course and, from this circumstance, it might be called, for distinction, the Windy Lake belt. The south-eastern boundary of this belt and the southern town-line of Levack intersect the river almost together, but at an angle with each other. Below this intersection the red hornblende-granite continues to be met with along the river for two miles, or to the junction of Windy Creek, below which the river enters upon the belt of dark silicious volcanic breccia and its underlying quartzite conglomerate. The falls of the Onaping River, close to the line of the Canadian Pacific Railway, are over this breccia. Between the foot of the falls and the junction of the river with the Vermilion, there are a few exposures of a coarse black slate, with large grains of quartz, overlying the breccia. The gneiss and hornblende-granite, above described, all along the Onaping River, are cut here and there by dykes of diabase, most of which have a northerly course.

THE STRAIGHT LAKE HURONIAN OUTLIER.

Its extent.

This irregular basin of the upper rocks has a breadth of eight miles on the line of the Canadian Pacific Railway. It sends a spur westward as far as Blue Water Lake, in the township of Craig, and a longer one south-westward to The Elbow of Spanish River. These have already been referred to in connection with the description of this stream. We

propose to call this basin the Straight Lake outlier, as its rocks and name deposits of economic minerals are already best known in connection with this lake and the railway station of the same name.

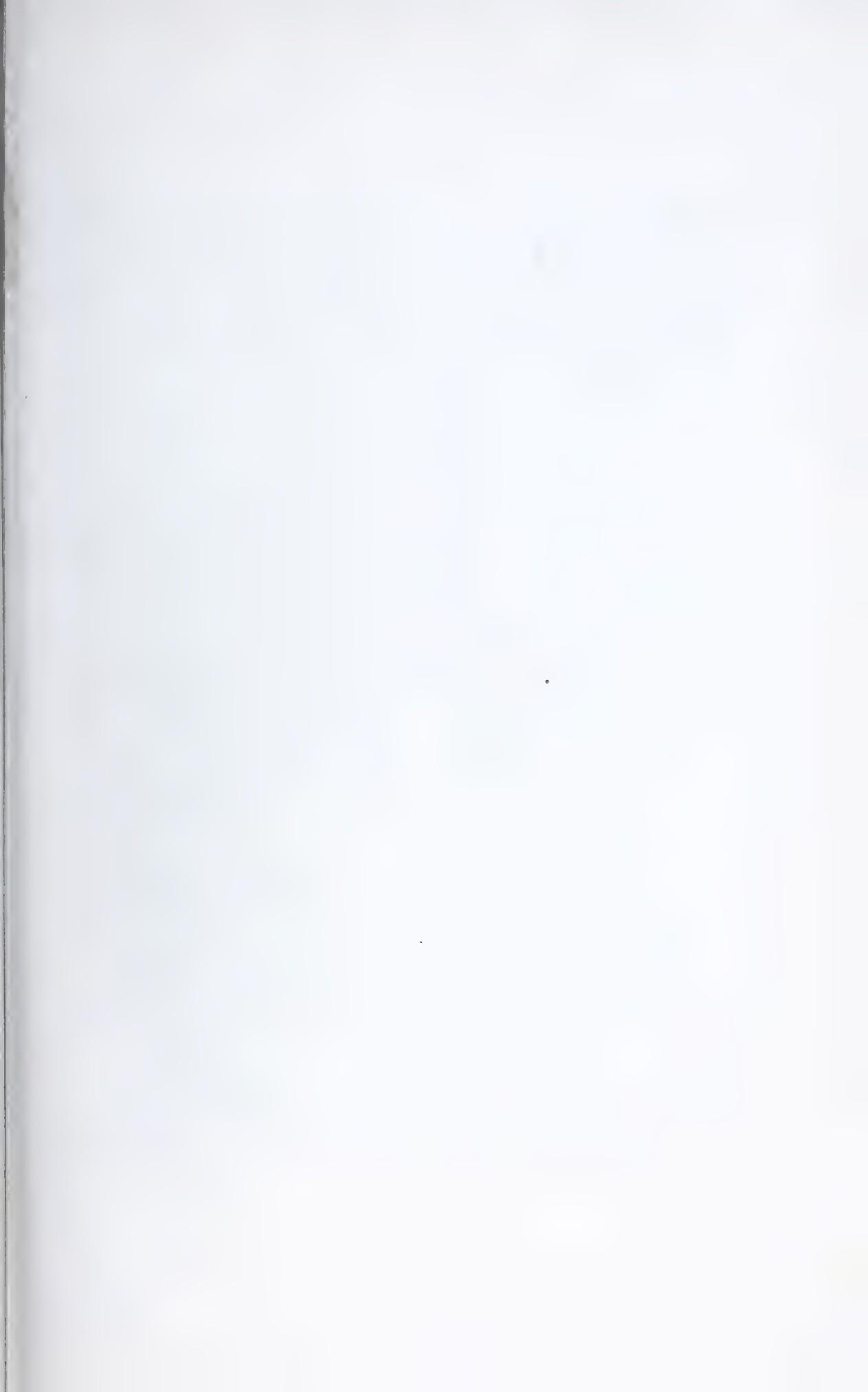
The rocks within it consist principally of greywacke-schists, quartzites, quartzite or greywacke-conglomerates, green schists, hard sandstones, greenstones and some dolomites. In addition to these, black slates occur upon the western side of the first hill west of the outlet of Geneva Lake, and also, to a small extent, close to the outlet itself.*

The eastern lobe of the outlier surrounds Geneva Lake and is almost separated from the rest of the basin. The Canadian Pacific Railway passes the outlet of this lake which is three miles north of Cartier station. Coming from the south-east, on the line of the railway, different varieties of the common red hornblende-granite of the district are found to extend for two miles and a-quarter beyond Cartier, but here the granite becomes mixed with coarse breccia and conglomerate. This is Coarse breccia. followed by ash-grey greywacke, 100 yards in width, and next by a bed of fifteen feet of grey to dove-coloured fine-grained dolomite, weathering dark brown. The dolomite strikes N. 45° E. and the bedding is about vertical. It is followed to the northward by coarse felsitic sandstone and silicious greywacke-conglomerate or breccia. The pebbles Conglomerate, and fragments in the latter weather out conspicuously and consist of other varieties of greywacke, hornblende-granites like the prevailing varieties found *in situ* in this region, black slate and black and white quartz. The strike varies from N. 30° to N. 60° E. These rocks continue, without change, for half a mile up the track and at the end of that distance they are found to enclose large masses or small areas of Enclosed masses. the greywacke, partially altered into fine-grained granite or syenite with all the outward appearance of the more thoroughly crystalline varieties. The rock also includes considerable masses of the latter and areas or patches of boulders of it crowded together, with the interstices filled by Patches of crushed or broken fragments of the same rock. At the outlet of Geneva Lake this syenite or granitic greywacke includes some black slate and a patch of impure dolomite thirty feet thick. A short distance northward of the outlet the greywacke becomes more argillaceous and shows lines of bedding dipping eastward at an angle of 45° , independent of the cleavage. Greywacke-conglomerate forms the shores of the outlet Conglomerate on west shore arm and of most of the western side of the lake, and it is also well seen of lake. along the railway track in the same vicinity.

The rocks of the eastern part of Geneva Lake consist principally of light yellowish-grey quartzite containing a good deal of felspathic matter, Quartzite. but the islands in the mouth of the large bay on the south-east side

*These are probably a continuation of a band of black slates near Bannerman Lake examined by Dr. Selwyn in 1883.

- Syenite. are formed of grey syenite, and an islet in the outlet arm is composed of the same rock. A mile and a-half north-east of the outlet there is an islet of thinly bedded light grey, dove-coloured and whitish dolomite. striking N. 35° E. and dipping to the westward side at an angle of 80° . The rock is compact and has a conchoidal fracture, but it is traversed by threads of quartz which prevent it from taking a good polish. The same dolomite band is exposed on the point just southward of the above islet, but it could not be found on the northern side of the lake towards which it strikes.
- Dolomite. At the north end of lot 1, con. I, Moncrieff, on the tote road at a distance of two miles north-north-west of Cartier station, the reddish hornblende-granite of the surrounding country becomes mixed with green diorite, having a dull fracture, enclosing fragments of grey granite and all mingled confusedly together forming a coarse breccia.
- Coarse breccia On the west side of this is a massive fine grained rock having the general appearance of syenite or granite, but apparently resulting from the alteration of massive greywacke. It is cut by numerous thin veins of quartz and fine grained magnetite, but the ore did not exceed six inches in thickness in any of the veins examined. A patch of brown-weathering dolomite, five or six feet in diameter, was observed in this rock. The hornblende-granite extends northward nearly to the fourth concession of Moncrieff.
- Altered greywacke. Magnetite. Dyke. Greywacke.
- Magnetite. On lot 4, con. III, Moncrieff, there is a dyke seventy-five feet wide and running a little east of north, composed of greenish-grey coarsely crystalline diabase. The late Mr. Salter mentions trap-rock as occurring on his meridian line at what is now the north-west corner of Moncrieff. This would appear to be in the run of the above dyke. The junction of the Laurentian red hornblende-granite, on the south, with the greywacke to the north occurs on the north end of the lot just mentioned. The latter rock is grey and somewhat thinly bedded and strikes S. 75° W. The tract between this and Bannerman Lake Lightgreenish is occupied by massive quartzite, some of which is of a light grassy quartzite. green colour. At the west end of Bannerman Lake, a small belt of hornblende-schist in the quartzite shows the strike to be S. 70° W. $< 90^{\circ}$.
- Elongated quartz pebbles. Agglomerate.
- The breccia or volcanic agglomerate on the railway, a short distance north-west of Bannerman Lake, has been referred to in describing the route to Onaping Lake. The 485th mile-board stands on this rock. Half a mile further north-west and continuing thence for half a mile on, or to the crossing of Onaping Creek by the railway, there is a dark blue or nearly black close-grained rock, holding long thin lenticular pebbles of grey quartzite. The strike is S. 60° W. In this interval, at a short distance north-east of the track, there is a ridge of coarse agglomerate. Quarter of a mile west



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H. TOPLEY, PHOTO.

ROAST YARD, COPPER CLIFF MINE, LOOKING EAST.

DESBARATS & CO., ENGR. & PR., MONTREAL.

of Onaping Creek, greywacke occurs, striking S. 65° W. Half a-mile further, in the same direction, a dyke of bluish-grey crystalline diabase, Diabase dyke. about 100 feet wide, appears and it continues parallel with the railway track—about W. N. W.—for a quarter of a mile. It weathers brown and decomposes at the joints and angles, leaving rounded or boulder-like masses. This brings us to the 487th mile-board. A dyke, which may be a continuation of the last, appears half a mile further on, and again on the north side of Straight Lake at a short distance east of the station of the same name. From the above mile-board to this station—about two miles and a-quarter—the country rock consists of grey slaty greywacke with small scales of light-coloured Slaty grey-wacke. mica on the cleavage planes, which dip about S. 20° W. $< 70^{\circ}$. Straight Lake station is near the commencement of the hornblende-granite and gneiss which continue thence all the way to the northern and western borders of the sheet.

GENERAL REMARKS ON THE ROCKS OF THE DISTRICT.

It will be seen from the foregoing report and from Professor Williams descriptions, that the Huronian rocks of the Sudbury district, as elsewhere, are largely of a volcanic nature. Many of them which are stratified and even distinctly sedimentary, may, nevertheless, have been primarily volcanic, but have become modified by the action of water. They have probably been volcanic ashes, dust, mud or other ejecta-menta and may have been thrown directly into the sea, as there was probably little land, or possibly none at all, at that stage of the earth's history. Even molten matter poured into the sea might easily break up to form some of these deposits, or if in sufficient mass it might remain nearly intact and finally cool in that position, afterwards becoming covered and incorporated in the sedimentary strata. The dark silicious breccia, which, with a thickness of several thousand feet, runs from the township of Trill nearly to Wahnapitæ Lake, affords positive proof of volcanic action with explosive violence, on a large scale. This rock may, however, be of Lower Cambrian age. Volcanic nature of Huronian rocks. Original state. Proof of volcanic activity.

The greywackes which constitute the most abundant class of rocks of the Huronian series in this district consist of granitic debris, more or less comminuted ; and, out of the same materials, by the modifying action of water, a considerable proportion of the other rocks of the series could have been and probably were formed. The commonest form of the greywacke is a grey or ash-coloured rock, which in hand specimens resembles sandstone, but on the large scale it seldom shows very distinct bed-planes and is generally massive or has a tendency to coarse slaty cleavage. It breaks more easily than quartzite and may

Greywacke described.

Varieties.

be readily bruised or scratched, showing that a considerable proportion of its components are softer than quartz. But under this name we may include several varieties, ranging from rocks approaching quartzites through different modifications, like sandstones, to others approaching argillites. At other times the rock is more or less filled with pebbles or broken fragments, or both, constituting conglomerates and breccias. Occasionally the finer materials act as a mere filling between closely crowded pebbles, angular fragments or boulders. With apparently similar composition and texture, the rock may be either roughly cleaved or slaty, or it may be amorphous. Both varieties may contain pebbles or fragments, or be tolerably free from them. The fragments, from the largest to the smallest size, usually consist of red and grey aplite or binary granite, and the matrix appears to be derived from the same rock, but in a more finely comminuted state. Most of the commoner varieties may be regarded as composed of this granite, reduced to a very finely fragmental condition, but with a considerable proportion remaining as good sized grains and small and large fragments.

Cleavable varieties.

Nature of enclosed fragments.

Slate-conglomerate.

When the greywacke becomes fine grained and slaty, with pebbles scattered through it, the rock may be called a slate-conglomerate, but the late Mr. Alexander Murray sometimes extended this term also to the more massive varieties containing pebbles and broken fragments, but without cleavage. In addition to granitic pebbles, the slate-conglomerates often contain others of red and black jasper and white quartz.

The greywackes appear to be susceptible of being easily restored to crystallic granite again. In many places the characters and conditions of the rock, as seen on the large scale, and also when examined by the microscope, show that this metamorphism is going on. Under different physical conditions and variations in the composition, felsite, granite and gneiss have been formed out of it. The quartzites and clay-slates alternate with each other, or are found geographically close together and they appear to have resulted from the separation and arrangement of the constituents of greywacke by water, the grains of quartz, with a greater or less mixture of those of felspar, being deposited by themselves to form the quartzites and the finer and lighter mud being carried further on to form the slates.

Metamorphism of greywacke.

Origin of quartzites and clay-slates.

Quartzites.

Quartzites diminish towards the N.E.

The quartzites of the Huronian system may be regarded as the more silicious forms of the same rocks or those varieties which have been rendered comparatively free from the felsitic or softer constituents of greywackes. It is worthy of remark that the quartzites which form so large a proportion of the Huronian rocks along the north shore of Lake Huron and thence inland as far as the Great Bend of the Spanish River and the township of Broder in the north-eastern extension of the

belt, diminish greatly in volume and pass into greywackes, and further on, into clay-slates, before reaching the eastern margin of the sheet. It would be noticed, however, from the descriptions in a former part of this report, that in the country to the northward of Lake Wahnapitæ, the quartzites again become largely developed. As a general rule the different subdivisions of the Huronian rocks in any region, do not maintain their thickness very far on the strike, but diminish more or less rapidly to a point, their places being at the same time filled by a corresponding thickening of the members on either side. The quartzites do not appear to form an exception to this condition, but owing to the fact that they withstand denudation better than the majority of the rocks associated with them, they become more conspicuous in proportion to their volume than the others, and their relative proportions are therefore apt to be over-estimated.

Again developed.

Prominence of quartzites.

The clay-slates and quartzites are generally closely associated together, and both are found in connection with the greywackes. This is the case in the country between the Wahnapitæ and Sturgeon Rivers, and the same thing was observed along Montreal River and between it and Lake Temagami. These slates are generally drab or bluish-green, or brownish and purplish. They are sometimes distinctly banded across the cleavage-plans; and at the northern outlet of Lake Temagami, where a handsome greenish variety occurs, they are streaked with irregular and interrupted black bars, which consist of hornblendic material. This variety was much prized by the ancient Indians as an ornamental stone and a variety of articles made from it have been found in many places in the Provinces of Ontario and Quebec and in several of the Northern States.

As already stated, the trappean rocks of the district consist of (1) Greenstones. extensive masses, together with many of smaller size, incorporated with the other Huronian rocks and probably contemporaneous with them, and (2) dykes which cut through all the members of the series. The following are the three principal varieties of the first class. Within the area of the first division shown on the sheet there are nearly fifty masses of highly crystalline diorite of a medium texture, and a dark green or greyish-green colour, characterized by the presence of disseminated spots and crystals of pyrite or sometimes of pyrrhotite or chalcopyrite. These masses constitute the first variety and they are generally, but not always, considerably elongated in the direction of the strike of the adjoining rocks. They measure from less than a quarter of a mile to about eleven miles in length. The strata among which they are included, being now highly inclined, these elongated masses may represent sections of what were originally overflows of the molten rock upon the then nearly horizontal surface, while those having

Fifty areas of diorite.

Elongated.

The reason.

more compact outlines may have filled hollows or they may have been early intrusive masses.

Character
of country.

These greenstone areas are not marked by any constant topographical characters by which they may be recognized. The surface of the country which they occupy does not differ from that of most other rocks, except in a few cases. These areas are diversified by lakes and streams, much in the same manner as that of the latter. This may be due to the fact that different parts of the same masses decompose differently under eroding agencies, some portions yielding readily, while others are hard and resisting.

Coarse grey
diabase.

The second variety is a massive grey rock, generally more coarsely crystalline than the last, and always appears to be a diabase or to consist principally of pyroxene and felspar. In this the above-mentioned sulphides are generally more sparingly disseminated than in the first class. There are two principal belts of this rock, both of them cutting the Laurentian and both having a general north-easterly and south-westerly course. One of them runs from Whitson Lake south-westward into the township of Creighton. It has a breadth of about one mile and a-half in the middle and diminishes regularly towards each end. The other large belt of this variety has been traced from the north-east portion of Levack south-westward across Windy Lake, nearly to Hyman, a distance of about eighteen miles. It is upwards of a mile wide in the middle and runs to a point in either direction. This has already been referred to as the Windy Lake belt, in describing the geology of the Onaping River. A third belt, about five miles long, from the vicinity of Sagi-tchi-wai-a-ga-mog Lake, runs south-westward into Morgan.

Windy Lake
belt.

The third variety is a more or less slaty greenish diorite, which in places becomes brecciated, the included fragments being of all sizes, from very large boulders down to small pebbles, and consisting principally of quartzites and granites or syenites. The diorite belt which borders the south-eastern side of the tongue of granite and gneiss from Garson to Graham belongs to this class, as does also the belt in the Vth and VIth concessions of Denison.

Coarse crys-
talline horn-
blende-rock.

There is also a very coarsely crystalline dark green amphibolite or hornblende-rock, examples of which may be seen on lot 4, concession V, Blezard, just east of the Stobie mine; along the north-west side of the same belt in the Vth concession of McKim; near the McConnell mine in the IVth concession of Snider, and again at the south-west bend of the Spanish River.

Quartziferous
hornblende-
rock.

A massive quartziferous hornblende-rock or diorite is not uncommon in the Huronian series in other regions, but in the Sudbury district we have what may be a form of this rock, modified by water—a rock which

may be called a stratified quartz-diorite. It is made up of rather thin beds, the lower part of each of which consists of a layer of quartz grains, the coarser being at the bottom and the finer higher up, while the upper part is a mixture of hornblende and felspar debris.

Reference has already been made to the apparent alteration of grey-wacke into granite in the township of Moncrieff and around Lower Lake Onaping and also as to the passage of another variety of grey-wacke into gneiss in the township of Hyman. Some of the gneiss on lots 10 and 11 in concession III of Garson bears a strong resemblance to the latter and it is possible that much of the gneiss of the long inliers of the contracted portion of the Huronian belt in the Sudbury district may have resulted from the metamorphism of greywacke.

In the centre of the township of McKim a belt of altered greywacke runs from the Copper Cliff mine and smelting works north-eastward to the VIth concession. Professor Williams describes an average specimen of this rock from lot 6 concession IV, about three-quarters of a mile north of Sudbury, as a pale grey compact felsite, and its components do not differ from those of unaltered greywacke except that they have lost their elastic appearance. On the railway track, one mile northwest of Sudbury, there is a more compact and silicious variety of this rock, which, on a fresh surface exposed in a cutting, shows bunches or spots, each a few inches in diameter, marked by long scattered imperfect crystals of black hornblende. At a short distance off these bunches have the appearance of foreign inclusions, but on closer examination they were found to be continuous with the rest of the rock. On lot 4, concession VI of McKim, about a mile south of the Stobie mine, where this belt of rock is pinching out, it shows a distinct gneissoid structure, both macroscopically and microscopically. In some places near the south-eastern margin of this area of altered greywacke, there is a rather fine-grained, ash-coloured rock, which might be called an altered volcanic mud, in some parts of which white grains of andesine are disseminated. Dr. Selwyn has called this variety "rice-rock." Examples of "Rice-rock." it may be found near the Canadian Copper Company's smelting furnace, on the hill north of Sudbury and again on lot 5, concession III of McKim. It also occurs at Lake Panache.

Gneiss and
felsite.

Hornblendic
bunches.

GENERAL CHARACTER OF THE HURONIAN ROCKS OF THE DISTRICT.

The descriptions of the field geology of the district in the foregoing Classes of pages and those of Professor Williams of the microscopical characters of the rocks contained in Appendix I, show that the Huronian belt in this district is made up of igneous or crystalline masses, metamorphic rocks derived both from these and from sedimentary strata, together with

unaltered or only slightly changed clastics, which have been generally sedimentary, but with some exceptions.

Their metamorphism.

Pyroclastic rocks.

Changes in massive diorites.

Nickel and copper.

Occurrences shown on map.

Area of occurrence.

Associated with the greenstones.

Notwithstanding the sedimentary character of a considerable proportion of these rocks, even they appear to have been nearly all derived directly from igneous or volcanic products, by undergoing a greater or less modification by water. Since their consolidation they have been subjected to metamorphosing influences, and have been more or less altered according to the different local conditions, such as their attitude, exposure to pressure, shearing, &c., as well as their own inherent susceptibility to change. They may, therefore, as a class, be appropriately termed pyroclastic. The primarily volcanic, as well as the derived rocks, have also undergone some degree of change, as, for example, in the case of the volcanic glass-brèccia above referred to, (whether Huronian or a little newer) where the pumice has been completely silicified, and again in the case of some of the diorites, which were originally massive, but in which a textural change and a schistose cleavage have been developed.

A careful study of these rocks, both in the field and under the microscope, in connection with such points as the above, might throw much light on various questions regarding the metamorphism of rocks in general.

ECONOMIC MINERALS.

Nickel and Copper.—In the Sudbury district these metals are so intimately associated as to make it necessary to describe them together. They occur as mixtures of chalcopyrite and nickeliferous pyrrhotite. In some instances the copper is in larger proportion than the nickel, but in perhaps the majority of cases the percentage of nickel predominates. The principal occurrences of these ores yet known are indicated on the accompanying map, from which it will be seen that they are always associated with the greenstones and also that their commonest situation is at the contact of these with some other rock, especially granite or gneiss. These mixed ores have now been found over an area extending on the strike, from the Wallace mine, on Lake Huron, north-eastward to the northern shore of Lake Wahnapitæ and transversely from the south-eastern boundary of the Huronian belt in this district north-westward to the western part of the Straight Lake outlier, beyond the Spanish River.

The ores are always found in intimate association with the greenstones, and in addition to the economic occurrences, these rocks always hold specks, crystals and often small patches of both pyrrhotite and chalcopyrite disseminated more or less abundantly throughout their mass. The existence of nickel in the sulphides of these greenstones





H. TOPLEY, PHOTO.

GENERAL VIEW OF MURRAY MINE, LOOKING NORTH-WEST.

was first ascertained by Dr. T. S. Hunt in 1856. Mr. Alexander Murray, assistant provincial geologist, in that year explored Salter's meridian line, running northward from Whitefish Lake and in what is now the township of Waters he found a "green magnetic trap," of which he says :* "Specimens of this trap have been given to Mr. Hunt for analysis and the result of his investigations shows that it contains magnetic iron ore and magnetic iron pyrites generally disseminated through the rock, the former in very small grains; titaniferous iron was found associated with the magnetic ore, and a small quantity of nickel and copper with the pyrites."

Mr. Murray visited the Wallace mine in 1848 and collected samples of the ore. In his report for that year (page 44) he says: "With a view of ascertaining the quality of the nickeliferous portion of the ore, a specimen of it, as free as possible from the copper pyrites, was submitted to analysis by Mr. Hunt, who found it to contain 8·26 per cent. of nickel with a trace of cobalt; but as nearly two-fifths of the specimen consisted of earthy materials, which might readily be separated by dressing, the quantity of nickel in the pure ore which this would represent would equal nearly 14 per cent."

In the Sudbury district, pyrrhotite is more generally diffused and more abundant than in any other known region of Canada and the unusual richness of this pyrrhotite in nickel, as compared with that of other parts of the Dominion, is somewhat remarkable. The latter circumstance may point to a common deep-seated origin of the accompanying greenstones, whether they occur at the surface among the Huronian or the Laurentian rocks.

The causes which brought about the deposition of the ore-bodies in their present positions and the mode of their formation are not very manifest.

It has been already stated that the larger ore-masses are found principally at the junction of the greenstones with some other rock. But there is also another circumstance which appears to influence the occurrence or localization of the ores, namely, the crossing of these lines of junction by lines of fracture or by the greenstone dykes which cut all the rocks. Some of the greenstones along certain lines hold abundance of angular fragments of other rocks, especially quartzites, and this brecciated condition appears to be favourable to the accumulation of the ore. This variety of the rock is found near the Dominion or Blezard, the Stobie, Copper Cliff, Crean and Vermilion mines.

The larger ore-bodies all resemble each other in most respects. Their general outline appears to be approximately lenticular, judging

First discovery.

Wallace Mine in 1848.

Abundance of pyrrhotite.

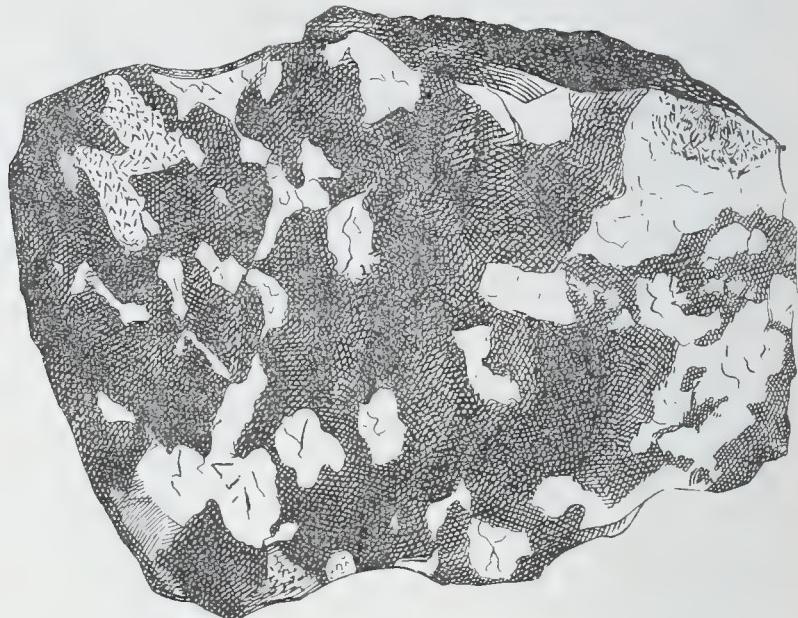
Determining causes.

* Report of Progress of the Geological Survey for 1853-56, page 180.

Brecciated mixture of ore and rock.

from the surface indications, but none of them have yet been sufficiently worked to prove their form, in depth. Their greatest superficial diameter is always parallel to the general strike of the enclosing rocks. In each case the ore-mass consists of a brecciated or agglomerated mixture of the pyrrhotite and chalcopyrite along with the country rock.

FIGURE 1.



This figure represents a specimen, natural size, of ore from the Copper-cliff Mine.

The shaded portion represents diorite.

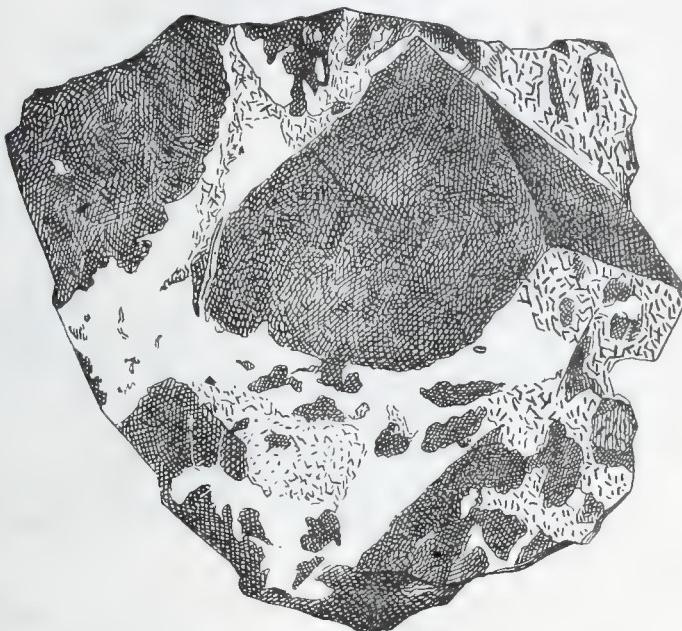
“ white	“	“	chalcopyrite.
“ hatched	“	“	pyrrhotite.

Mixed sulphides.

The included fragments of the latter are both rounded and angular, and vary in size from that of pebbles to large boulders, but the average is a few inches in diameter. Immense blocks or "horses" also occur in the midst of the ore, and at the Stobie mine some masses of the country rock run through the deposit in the form of thick walls or partitions, both transverse to and parallel with the general strike. Where the stony inclusions are widely separated, large quantities of the mixed sulphides have accumulated between them, but where the former are closely crowded together the amount of ore is correspondingly small. Besides being frequently intimately mixed together in the form of grains, the two sulphides are also commonly intermingled as spots and patches of all sizes. When the pyrrhotite is the more abundant ore, the patches of chalcopyrite may be said to be incorporated in it and vice versa, but the two interlock or ramify with each other so intimately that it is

impossible to separate by mechanical means even the coarser portions for metallurgical treatment, to say nothing of the finer mixture in the form of grains

FIGURE 2.



This figure represents a specimen, $\frac{3}{4}$ natural size, of ore from the Murray Mine.

The shaded portion represents diorite.

" white " " chalcopyrite.

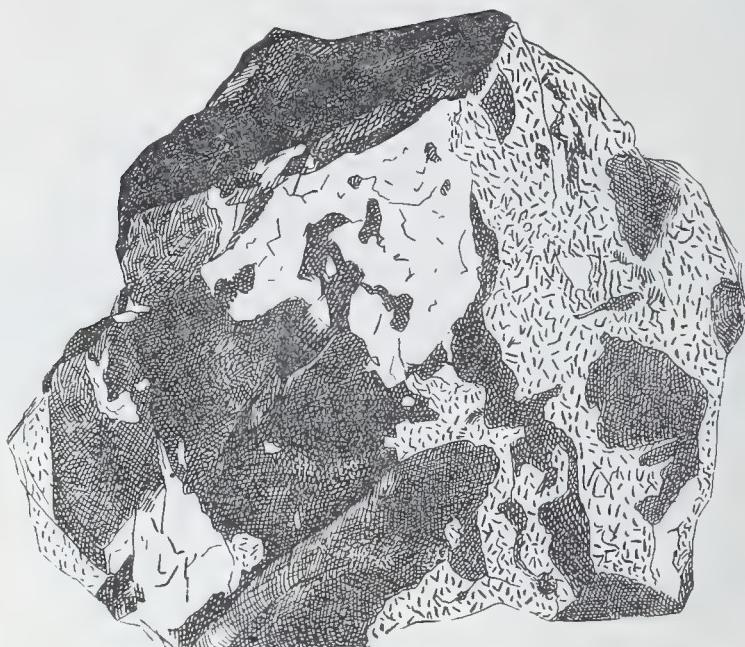
" hatched " " pyrrhotite.

The chalcopyrite of the larger patches is generally nearly pure, but the pyrrhotite is almost always mixed with a considerable percentage of stony matter in the form of large and small grains. This may indicate that the former has been segregated out of the mixture by some secondary process subsequently to the general deposition of the mass. The chalcopyrite often shows a tendency to run in the form of branching strings or to partially surround the smaller stony inclusions. In one of these brecciated ore-deposits which occurs on lot 3, con. V of Levack, the spaces between the greenstone fragments are sometimes filled partly by pyrrhotite and partly by light-coloured crystalline granitoid vein-matter. This circumstance may be of interest in connection with questions as to the mode in which the spaces between the rocky fragments in all these deposits have been filled with ore.

The general character of the deposits seems to indicate that they have originated primarily from a state of fusion. Their intimate origin of the ore.

association with greenstones, which are of igneous origin, would show this, as well as the fact that these greenstones themselves fuse at

FIGURE 3.



This figure represents a specimen, $\frac{2}{3}$ natural size, of ore from the Stobie Mine.

The shaded portion represents diorite.

" white " " chalcopyrite.

" hatched " " pyrrhotite.

about the same temperature as the sulphides. But they may have been subsequently more or less modified by other agencies. The occurrence of crystals of felspar, quartz and apatite in some of the deposits, and of laminated iron pyrites in one place in the Copper Cliff mine indicate the action of aqueous solution.

Possible partial modification by solution.

Greenstones impregnated with the sulphides.

Continuation of ore-bearing belt of Stobie mine.

The greenstone wall-rocks of the deposits, as well as the included fragments of the same material, are generally much impregnated with these sulphides in the form of isolated globules or kernels, usually from the size of peas to that of hazel nuts, besides irregular strings and patches. A fresh surface of the rock will in one case show the two sulphides in separate spots thickly intermingled, while another section may show the spots to consist entirely of the one or the other. These disseminated sulphides exist in all proportions relatively to the greenstone matrix until they replace more than half the latter and constitute a self-roasting ore. To the south-west of the Stobie mine in the strike of the principal deposit there, smaller ore-masses are found for a distance of more than a mile, and these are connected with each other by a belt of somewhat slaty diorite full of disseminated ore of this kind. These impregnations have not been found in the clastic

rocks adjoining the greenstones at any of the deposits, while their abundance in the latter rocks goes to show that the larger or more concentrated deposits have also had an igneous origin like the smaller ones enclosed in the diorite.

At the Vermilion mine, on lot 6, con. IV, Denison, a shaft called Copper. No. 1 had been sunk in diorite to a depth of about twenty feet on a promising vein of chalcopyrite. On exposure to the weather, the ore is remarkable for becoming tarnished of a deep purplish blue colour Blue tarnish. like that of bornite. The vein occurs in diorite, and is about four feet wide, but without distinct walls or any veinstone except a mixture of the country-rock. The upper ten feet were decomposed to a loose gossan, holding fragments of rock. The new mineral Sperrylite Sperrylite. (arsenide of platinum with a little tin) was found by washing this material, and Mr. R. R. Hedley informed me that he had found 12 dwts. of gold to the ton in one assay of ore from this shaft. A few specks of gold were seen in iron-stained spots on the weathered surface Gold. of the diorite close to the shaft. At about fifty yards to the southward of the shaft, massive beds of quartzite and greywacke terminate abruptly almost at right angles against the cleavage of a dioritic schist holding large and somewhat angular fragments of quartzite, along with many small ones, all mingled together. A belt of diorite runs east and west across the township of Denison, in the Vth concession, and Across Deni- son. along its southern border, copper pyrites has been found on almost every lot, but as yet no openings have been made to test the extent of these deposits. Two or three masses of a fine-grained mixture of py- Pyrite and blonde. rite and blonde occur on lot 10, con. VI of Creighton. They are said to be large, but we had not an opportunity of examining them.

The mines from which ore has been sent to market or smelted in the district are the Stobie, the Copper Cliff and the Evans belonging to the Canadian Copper Company, the Blezard and the Worthington belonging to the Dominion Mineral Company, and the Murray mine belonging to Messrs. H. H. Vivian & Co. In order to ascertain the average percentage of nickel and copper as determined by the treat- Percentage of ment of large quantities by these companies, I applied to the secretary metals in the ores. of the Canadian Copper Company and the managers for the other two companies, all of whom have kindly furnished me with the desired information. On 18th March, 1891, Mr. H. P. McIntosh, secretary of the Canadian Copper Company wrote: "The output of our mines for last year averaged as follows:—

	Copper.	Nickel.
Copper Cliff mine.....	6·24 per cent.	3·69 per cent.
Evans mine.....	2·84 "	3·62 "
Stobie mine.....	1·99 "	2·00 "
Average of all.....	4·32 "	3·52 "

Mines of the
Canadian
Copper Com-
pany.

You will note that the average of the total output is more than one-third the total of the three mines ; this is accounted for by estimating the average according to the amount of ore mined, which is the proper way. We have not done sufficient work at the Vermilion to give you any reliable data, but the ore taken out there, now on the dumps, assays about 16 per cent. copper and about 13 per cent. nickel."

Mines of the
Dominion
Mineral
Company.

Mr. George Attwood, M.E., manager for the Dominion Mineral Company, under date of 18th March, 1891, wrote: "The 'Kies' or metallics of the Blezard mine average 4 per cent. nickel which is accompanied by about 2 per cent. copper. The above is the result of many hundreds of assays, also of the practical working on a large scale. The nickel ore at the Worthington varies very much, and we have had assays from 2 per cent. to 38 per cent. nickel. Large shipments of clean ore have gone about $9\frac{1}{2}$ per cent. nickel and 3 per cent copper. We have also shipped some clean copper ore from the Worthington mine assaying 18 per cent. copper and $2\frac{1}{2}$ per cent. nickel."

Vivian Co.'s
mine.

Mr. F. R. W. Daw, manager for Messrs. H. H. Vivian & Co., writing on 20th March, 1891, said: "The average percentage of the ore smelted here (Murray mine) is as follows :—Nickel 1·5 per cent., copper 0·75 per cent. The matte or first metal will average 8·5 per cent. for nickel and 4 per cent. for copper."

Range of
nickel con-
tents.

The percentage of nickel in samples of the pyrrhotite ores from the numerous deposits of the district has generally been found to range from less than 2 per cent. to nearly 5 per cent., while selected specimens of the sulphides of nickel found at some of the mines have given from about 30 to 40 per cent.

Rich nickel
ore.

The Dominion Mineral Company has shipped in the spring of 1891, a small quantity of dressed ore from the Worthington mine, containing in the neighbourhood of 30 per cent. nickel.

Proportions
of nickel to
copper.
Mr. Sperry's
tests.

From the description already given of the mixed nickel and copper ores of the Sudbury deposits, it would naturally be expected that the relative proportions of these metals would vary greatly. These variations are illustrated by the following tests : Mr. F. L. Sperry, late chemist to the Canadian Copper Company, in November, 1888, made assays of nine different samples of the ores from the mines of this company, and found them to show extremes of 1·12 per cent. and 4·21 per cent. of nickel, the average being 2·38 per cent. and of 4·03 per cent. and 9·98 per cent. of copper, the average of the latter being 6·44 per cent. Mr. G. C. Hoffmann, chemist to the Geological Survey, had, in 1890, assayed four samples* of pyrrhotite from as many different

Mr. Hoff-
mann's tests.

* Collected at the following localities :—

Nairn, lot 2, con. III. Nickel, 1.95, with traces of cobalt.
Lorne, lot 11, con. V. Nickel, 1.95 with traces of cobalt.
Drury, lot 3, con. III. Nickel and cobalt, 2·01.
Neelon, lot 12, con. III. Nickel, 3.10.

deposits in the district, and found from 1·95 per cent. to 3·10 per cent. of nickel, the average being 2·25 per cent. Since that time, by your direction, analyses of eight samples of these ores from seven different localities have been made in the laboratory of the Survey with the following results:

They show the percentage of nickel contained in the samples just as they were collected, or without the separation of any portion of the gangue.

1. From S. $\frac{1}{2}$ lot 6, concession II, Denison. Pyrrhotite disseminated through a quartzose gangue. It contained nickel, 1·55 per cent.; cobalt, none.

2. From lot 7, con. II, Levack. Pyrrhotite disseminated through a quartzose gangue. It contained nickel, with a trace of cobalt, 2·36 per cent.

3. From lot 7, con. II, Levack (from a different part of the same deposit as the last). A coarse-grained pyrrhotite. It contained nickel, 4·13 per cent.; cobalt, none.

4. From lot 3, con. IV, Levack. Pyrrhotite with a little copper pyrites in a gangue of diorite. It contained nickel, with a trace of cobalt, 1·96 per cent.

5. Ross Location, 3 miles north of the centre of the north town-line of Morgan. Pyrrhotite with a small amount of copper pyrites. It contained nickel, 2·75 per cent.; cobalt, none.

6. Location W 7, east side of Waddell's Lake. Pyrrhotite with a little copper pyrites in a gangue of diorite. It contained nickel, 2·00 per cent.; cobalt, none.

7. Boucher's mine on the north-east side of Lake Wahnapitæ. An intimate association of copper pyrites in a gangue of diorite. It contained nickel, 1·57 per cent.; cobalt, none.

8. Vein on lot 10, con. VI, Creighton. An association of a dark grey schistose rock and white quartz, carrying zinc-blende and some pyrrhotite. It contained neither nickel nor cobalt.

The above results are not intended to apply to other than the particular specimens examined.

Lead and zinc.—Galena and zinc-blende have been found, but, as yet, Lead and zinc apparently; only in small quantities, at several places in the belt of black slate and volcanic breccia. One of these is on lot 4, con. V of Fairbank, near the outlet of Vermilion Lake; another is on lot 8, con. IV of Dowling, near Onaping Falls, and a third occurs on the Pawatik or Rapid River, about a mile and a-quarter from Vermilion River, where Mr. Stobie informed me he had found these ores in small quartz veins cutting the breccia. A vein of blende and pyrite on lot 10, con. VI of Creighton, has been already mentioned.

Galena has been found in small quantities with the pyrrhotite at the Copper Cliff Mine, and on lot 6, con. III of Graham. It also occurs in small quartz veins in dioritic schist on lot 5, con. IV of Denison.

Gold.

Gold.—Fifteen samples collected in 1890 were submitted to Mr. Hoffmann for assay for gold and silver, and the following are his results:—

15 assays.	Locality.	Gold, per ton of 2,000 lbs.	Silver, per ton of 2,000 lbs.
	Sinon Obensoing's mine on lot 8, con. III of Moncrieff— Quartz, honeycombed by the dissolving away of iron pyrites	Trace.	None.
	Vein of quartz, 50 feet wide, and running N. and S. on W. side of Little Clear Lake, 2 miles W. of dam at outlet of Lake Wahnapitæ	None.	do
	Vein 9 inches wide on East side of Waddell's Lake	Trace.	do
	Vein No. 1 on mining location W.R. III, township 40 (S.E. of Lake Wahnapitæ). Property of Mr. Donald McLaren	0·117 oz.	do
	Vein No. 2 on same location	None.	do
	Location M. III, at S. extremity of Lake Mattagamashing, a short distance N. E. of Lake Wahnapite. Property of Donald McLaren	1·167 oz.	0·233 oz.
	Near line of C.P. Ry. 480½ miles West of Montreal	Trace.	None.
	N. E. corner township of Plummer. Silicious veinstone containing grey copper ore. From Mr. James Stobie. Middle of large vein of bluish-grey quartz, Ophir mine, Lot 12, con. III, Galbraith	do	do
	Foot or North wall, West end Ophir mine	0·175 oz.	do
	Hanging, or South wall, West end Ophir mine	Trace.	do
	Near hanging wall, Eastern opening Ophir mine	do	0·175 oz.
	Lot 5, con. IV, Denison, No. 3 shaft	0·583 oz.	None.
	E. ½ Ross location, 3 miles N. of middle of N. townline of Morgan (decomposed pyrites)	Trace.	0·525 oz.
	Simpson's mine, lot 11, con. II, Graham, near Whitefish Station on C. P. Ry.	None.	None.
		0·350 oz.	do

Gold-bearing veins.

Numerous veins of quartz, some of which are of large size, have been discovered in the north-western part of Creighton and the eastern part of Fairbank. Their general course is N.N.E. Openings have been made on some of these veins by Mr. J. R. Gordon and specimens sent for assay to Prof. Heys, of Toronto, and others, who report the occurrence of gold in several instances.*

Limestone.

Magnesian limestone.—The purer deposits of dolomite which have been described as occurring at Lake Panache and also those of Geneva Lake and near Cartier Station, as well as the band which crosses Wahnapitæ River at the Island Portage, are apparently suitable for burning into lime, and they may also be found useful in connection with metallurgical processes in the district.

* Specimens of quartz from gash veins in these townships have been assayed by Mr. Hoffmann with the following results:—

Fairbank, lot 2, con. IV. No gold or silver.

Creighton, lot 11, con. V. No gold or silver. (Two assays.)





H. T. JONES, PHOTO.

MATTE IN STOCK, COPPER CLIFF MINE.
July, 1890.

(P. N. SHAW & CO., PRINTERS & PUBLISHERS, MONTRÉAL.)

APPENDIX I.

NOTES ON THE MICROSCOPICAL CHARACTER OF ROCKS FROM THE SUDBURY MINING DISTRICT, CANADA.*

BY PROF. GEORGE H. WILLIAMS, Ph. D. (of Johns Hopkins University).
(Collected in 1889-90 by Dr. Robert Bell.)

The suite of rocks from the Sudbury mining district entrusted to me for examination consists of forty-seven specimens, exclusive of two from Labrador and one from Hudson's Bay.

These rocks consist largely of distinct clastics derived from granitic or gneissic debris. With them occur many undoubted eruptives, whose origin was contemporaneous or subsequent to the deposition of the clastics, and with which the origin of the ores appears to be intimately connected.

Both clastics and eruptives have been subjected to extensive metamorphism and recrystallization, which has frequently resulted in the partial or complete obliteration of the original structure. The writer has frequently insisted (Bull. U.S. Geol. Surv., No. 28, p. 9; Bull. Geol. Soc. Am., Vol. I, p. 552; etc.) that a definite sequence of physical condition may produce from rocks of the most diverse origin, ultimate results that are indistinguishable. An eruptive granite and a sedimentary arkose may, under like conditions, be so recrystallized and metamorphosed as to produce gneisses which the microscope cannot separate and upon whose origin this instrument is able to throw no certain light.

As illustrations of progressive changes of this character in both clastic and eruptive rocks, this suite of specimens from the Sudbury region is particularly instructive. We may find the typical arkose with its felspar just beginning to break down into sericite (Nos. 22 and 25); and we may trace this alteration to the development of a continuous sericite matrix in which the quartz grains of the original rock are imbedded (No. 8, 9, 12, 13, 18, etc.). In similar rocks we may also see the new crystallization biotite, epidote or chlorite. In this way gneisses may result which retain little or no trace of clastic structure, and which might have originated from the crushing of a granite (Nos. 19, 23, 26, 27, 30). Hence it is not to be wondered at that the origin of certain of the holocrystalline rocks must always remain in doubt.

* A similar collection of rocks from the Sudbury region has been described by Prof. T. G. Bonney (Quart. Jour. Geol. Soc., vol. 44, p. 32, Feb., 1888), who reaches about the same general conclusions in regard to them as the present writer.

Many of the intrusive rocks still retain, even when greatly weathered, the unmistakable signs of their true character and source. But these masses, like those of clastic origin, are subject to metamorphism and recrystallization under altered physical conditions, which may in time obliterate entirely the minerals and structures that are such certain guides as long as they survive. Such changes we may see in progress in the Copper Cliff rock (No. 5) while enough of the original character remains to definitely fix the nature of the mass. In Nos. 32 and 40, however, the metamorphism has progressed so far that we are only warranted in assigning the rocks to the class of eruptives, after having traced out the progress of their alterations step by step. No. 43 affords another example of such changes in progress in eruptive rocks, where, however, the nature of the alteration is quite different from that seen in No. 5.

Apart from their alterations, some of the eruptive rocks of this collection possess an unusual intrinsic interest. This is noticeably the case with No. 46, quartz-hypersthene gabbro; No. 39, variolite; No. 43, hornblendic pyroxenite; Nos. 35 and 42, vitrophyre tuff; and No. 47, micropegmatite.

Appended is a classified list of the fifty specimens, followed by descriptions of each one in regular succession.

I.—ROCKS WHOSE CLASTIC STRUCTURE IS PLAINLY VISIBLE.

- No. 1. Conglomerate. West side of largest island in the west bay of Wahnapitæ Lake.
- 24. Conglomerate sandstone or greywacke. South side of Bay Lake, Montreal River.
- 20. Conglomerate sandstone or greywacke. Five miles N. E. of inlet of Echo Lake, St. Mary's River.
- 9. Coarse arkose with sericite matrix. East side of Maple Mountain, South of Montreal River.
- 8. Finer arkose with sericite matrix. Sturgeon River, near junction of Obabika River.
- 12. Arkose with little sericite matrix. South side of Little River, Lake Temiscaming.
- 18. Arkose with much sericite matrix. Thirteen miles up Upper Wahnapitæ River.
- 22. Arkose with felspar in process of sericitization. Montreal River, four miles above Temagami Branch.
- 25. Arkose with felspar in process of sericitization. N. E. side mountain, near Wendabin's House, Lady Evelyn Lake.

- No. 13. Quartzite grit with sericite matrix. High Pond, east side of Maple Mountain.
 17. White sandstone, with kaolinized felspar. Four miles N. E. of inlet of Echo Lake.
 28. Felspathic sandstone or quartzite. Gold Mine, south side of Wahnapitæ Lake.

II.—ROCKS DISTINCTLY CLASTIC, BUT PARTIALLY RECRYSTALLIZED.

- No. 36. Stretched quartzite. Three miles up West Branch of the Spanish River.
 41. Arkose with granite fragments partially recrystallized. Quarter of a mile N. W. of Copper Cliff mine.
 33. Sandstone, partly recrystallized. The Hill, north side of Sudbury Village.
 14. Greywacke, with iron in felspar. $455\frac{1}{2}$ miles west of Montreal, on main line of Canadian Pacific Railway.

III.—HIGHLY CRYSTALLINE ROCKS, PROBABLY DERIVED FROM CLASTICS.

- No. 6. Felsite. Canadian Pacific Railway track, between Sudbury and the Murray mine.
 7. Felsite. 300 yards east of the Copper Cliff mine.
 15. Felsite. North side of Copper Cliff mine.
 16. Felsite. Southern part of Lady Evelyn Lake.
 19. Felsite. Foot of first portage below Rabbit Lake, between Lakes Temagami and Temiscaming.
 23. Biotite epidote gneiss conglomerate. Three-quarters of a mile N. W. of Copper Cliff mine.
 27. Metamorphosed greywacke conglomerate. 200 yards S. E. of Copper Cliff mine.
 26. Biotite gneiss. Railway track, one mile south of Stobie mine.
 30. Sericite chlorite gneiss. Smelting furnace, Copper Cliff mine.

IV.—ROCKS WITH NO INDICATIONS OF CLASTIC ORIGIN.

- No. 2. Granite (with allanite?) West side of largest island in west bay of Lake Wahnapitæ. (In contact with No. 1.)
 3. Granite. Same as last.
 4. Granite. Same as last.
 11. Coarse granite. One mile south of Crow's Nest Rock, west side of Lake Temiscaming.
 31. Fine hornblende biotite granite. Ridge three-quarters of a mile west of Stobie mine.

- No. 45. Crushed granite. Canadian Pacific Railway line, half a mile S. E. of Murray mine.
- 34. Garnet augite gneiss. West town-line of Hyman, two and a-half miles north of Spanish River.
- 44. Garnetiferous hornblende schist. Vermilion mine, one-third of a mile S. W. of the boarding house.

V.—UNDOUBTED ERUPTIVES.

- No. 5. Uralitic gabbro. Shaft of Copper Cliff mine.
- 10. Similar rock, much more altered. Wall rock of shaft No. 2, Vermilion mine.
- 10. Similar rock, still more altered. Wall rock of shaft No. 2, Vermilion Lake.
- 32. Fine-grained diorite (cf. No. 5.) Ridge west of Stobie mine,
- 40. Hornblende schist or amphibolite. Murray mine.
- 35 & 42. Vitrophyre tuff. Lowest High Fall of the Onaping River.
- 46. Quartz-hypersthene gabbro. Dyke at Blezard mine.
- 48. Olivine diabase. Great dyke at foot of fifth portage, Spanish River.
- 49. Diabase (altered). Country rock of the Bruce mines.
- 39. Variolite. Ottawa Islet, Hudson Bay.
- 38. Diabase porphyrite. Nachvak, Labrador.
- 43. Hornblende pyroxenite (changing to talc). Nachvak, Labrador.
- 47. Micropegmatite. Eagle Rock Lake, Township of Levack.

DESCRIPTIONS OF THE ABOVE ROCKS.

No. 1. *Greywacke Conglomerate*.—West side of the largest island in West Bay, Lake Wahnapitæ. Well rounded granular quartz-felspar pebbles, two inches in diameter, cracked and scaled, imbedded in a fine compact black matrix. Section shows the pebbles to be made up of large felspar grains (mostly orthoclase) which are much broken and displaced. They further show indication of having been squeezed, in an undulatory extinction. These felspar grains are cemented by a recrystallized mosaic of chalcedonic quartz grains, which varies considerably in its fineness. It is well known that, under intense dynamic action, the quartz of a rock may be completely recrystallized into a mosaic of interlocking, fresh looking grains, while the felspar retains its original character and is only broken or optically disturbed. (cf. Rosenbusch, Mass. Gest., 2nd Ed., p. 41 ; Lehmann, *Altkristallinische Schiefergesteine*, p. 250.)

The microscope shows the fine-grained matrix in which these pebbles are enclosed, to be composed of very minute sericite scales, which have resulted from the decomposition of felspar substance, together with extremely small quartz grains. This clay-like matrix contains numerous small angular fragments of quartz, orthoclase, and plagioclase. The structure of this rock is in every respect typically clastic, and it may be designated as a greywacke-conglomerate.

No. 2. *Granite*.—Same locality as No. 1. Rock of medium grain and somewhat porphyritic, through the presence of larger crystals of white orthoclase.

The section shows ordinary granitic quartz with fluid inclusions; orthoclase in large individuals, as well as in the finer-grained portion of the rock; plagioclase (oligoclase); and biotite, which is altered to chlorite, either wholly or in part. This section also contains a deep brown mineral, which is probably allanite. It is surrounded by a rim of epidote, as in the allanite-granites of Maryland. (cf. W. H. Hobbs: Am. Jour. Science (3) xxxviii, p. 223; and Tschermak's Min. and Petrog. Mitth. xi, p. 1, 1890). This rock shows the evidence of dynamic action to a slight degree, but has not the faintest indication of clastic origin.

No. 3. *Granite*.—Same locality as Nos. 1 and 2. This rock is a granite like the last, except that it has a finer and more even grain, *i.e.*, is without porphyritic crystals.

The section shows under the microscope granitic quartz, orthoclase, plagioclase, biotite, with a little magnetite and pyrite. The biotite is much less altered than in the preceding specimen, showing only occasional chloritization in streaks. There is no allanite or epidote observable in this section.

No. 4. *Granite*.—Same locality as Nos. 1, 2 and 3. The specimen is much darker and finer-grained than the last described rock, but the two varieties closely resemble one another.

The microscope shows granitic quartz, orthoclase extensively kaolinized, plagioclase, and biotite which is about half altered to chlorite. There is also some magnetite and pyrite.

This section is traversed by a narrow vein composed of quartz, orthoclase, plagioclase and chlorite. It is worthy of note that all the felspar of this vein presents a striking contrast to that of the rest of the rock in being quite clear and fresh. The place of the biotite of the granite is, however, here wholly taken by chlorite. There is also in this vein an extremely fibrous mineral in matted tufts. It is closely related to the chlorite and may be chrysotile or asbestos. The grain of this rock is fine; its structure is typically granitic.

No. 5. *Uralitic Gabbro or Gabbro Diorite*—Shaft, Copper Cliff mine. Country-rock of the Copper Cliff copper-nickel pyrites.

A medium-grained massive greenstone or trap, containing both chalcopyrite and pyrrhotite. This rock is undoubtedly of eruptive origin, and from its present mineralogical composition it might be called a biotitic diorite. Both its hornblende and biotite are, however, of secondary origin, and have been derived from some pre-existing constituent which was in all probability pyroxene.

The microscope shows that the light portions of this section are composed of an interlacing network of idiomorphic felspar laths, whose fine striations show them to be plagioclase. The union of these felspar crystals to considerable irregular areas free from bisilicate prevents their producing a typical diabase or ophitic structure in the rock. The place of this felspar toward the more acid end of the plagioclase series is indicated by its local alteration to kaolin, rather than to calcite. Most of the felspar is penetrated by minute hornblende needles, and it is also often sprinkled with magnetite. Associated with the felspar are apatite needles, and a relatively small amount of quartz which fills up the interstices between the felspar laths.

The ferro-magnesian constituents of this rock (hornblende and biotite) are, like the felspar, grouped into aggregates which occupy irregular areas. The hornblende is dark green and strongly pleochroic. It occurs in clusters of small needles and grains which by their arrangement and structure bear every evidence of being secondary after pyroxene. The hornblende of the outside of these clusters is more compact and more darkly colored than that in their centre; and, while the remains of a pyroxene core could not in any case be definitely substantiated, the resemblance of this to other hornblende is too close to be mistaken. (cf. G. H. Williams: Gabbros and Associated Hornblende Rocks of Baltimore, Md., Bull. U.S.G.S., No. 28, Pl. I, Fig. 2, Pl. II, Fig. 1. Max Schuster: Neues Jahrbuch für Min., etc., Beil. Band V, p. 565.)

The biotite, which is less in amount than the hornblende, is of a copper red color and strongly pleochroic. It also bears strong indications of secondary origin. Both the hornblende and the biotite, but especially the latter, surround the ore (pyrite) in a way to suggest that the metamorphism to which they owe their origin, was in some way genetically connected with the deposit of the copper and nickel.

There can be little doubt that this rock was once an intrusive gabbro or diabase, which, owing to some subsequent metamorphism, has had its pyroxenic components changed to secondary hornblende or uralite. During the chemical and molecular changes which brought about the alteration, the felspar was filled with minute hornblende

needles, biotite was produced, and perhaps the copper and nickeliferous iron sulphides took their present form and position.

No. 6. *Microgranitic Rock* (possibly a recrystallized clastic arkose or greywacke).—One mile north-west of Sudbury. Appears to the unaided eye as a pale grey felsitic mass, without prominent grains or porphyritic crystals.

The microscope shows the slide to be composed of an evenly granular mosaic of quartz and felspar (orthoclase), interspersed with an abundance of biotite and considerable muscovite. Highly refractive epidote granules also occur and the biotite is rarely altered to chlorite. Traces of pyrite are also present.

The rock is not typically granitic, and yet it bears no certain evidence of clastic origin. The quartz and felspar grains interlock, and the biotite has evidently originated *in situ*. No outlines of originally clastic grains can be detected, though it is not impossible that this specimen may represent a metamorphosed and recrystallized clastic composed of granitic minerals.

No. 7. *Microgranitic Rock*.—300 yards east of Copper Cliff mine. A pinkish grey felsitic rock, much like the last described.

The microscope shows the structure of this rock to be much like that of the last described. Its composition is also similar, except that biotite is absent. Muscovite also is present in much smaller amount. The ferro-magnesian silicates are very sparsely distributed, and are mostly chlorite, with perhaps a trace of green hornblende. Epidote is present as in No. 6. The rock is mostly an even mosaic of quartz and felspar grains (orthoclase and microcline), the latter mineral being much more abundant than in No. 6. It is often stained with iron hydroxide which gives the pinkish tinge to the rock. The microscopic evidence of the genesis of this specimen is about the same as that obtained for the preceding (No. 6). The two succeeding specimens (8 and 9), although to the unaided eye apparently quite like the last two, are shown by the microscope to possess a typically clastic structure, which places their fragmental origin beyond all doubt.

No. 8. *Arkose Sandstone or Greywacke*.—Sturgeon River near junction of the Obabika. Pale greenish-grey fine grained rock of felsitic appearance.

The microscope at once disclosed the pronounced fragmental character of this rock, which is not so apparent to the unaided eye. Angular or slightly rounded grains of less than a millimetre average diameter, are imbedded in a fine felt-like matrix consisting principally of sericite (hydromica or kaolin). The angular grains are of the granitic minerals, quartz, orthoclase, microcline and oligoclase, with rarely a granule of reddish zircon. One fragment of well marked nicropege-

matite (granophyre) was also observed. The grains vary much in size and shape. Many of them are broken and their pieces only slightly dislocated. There is no mica in this rock, but there is a little chlorite, filling the narrower interstices between the grains.

The ground mass or cement of this rock is proportionately small in quantity. It is a confused mass of minute sericite scales, being the argillaceous product of decomposing felspar substance.

No. 9. *Coarser reddish Arkose*.—East side of Maple Mountain, south of Montreal River. This specimen, upon a superficial examination, does not look unlike a rather fine-grained granite. It is, however, a clastic arkose sandstone like the last, but of somewhat coarser grain. The grains are mostly angular, and often much fractured. They consist of quartz, orthoclase and plagioclase. Neither mica nor chlorite occur in this section, except as a component of the sericite ground-mass or cement, which is here relatively more abundant than in the last-described specimen. Stains of ferric hydroxide are abundant and impart the reddish color to the rock.

No. 10. *Greatly altered Greenstone (Gabbro?)*.—Shaft 2, Vermilion mine, Denison. The country-rock of the auriferous quartz vein.

A fine-grained, evenly granular, greenish grey rock, with a somewhat silvery lustre.

The microscope shows this to be an extremely changed basic eruptive, probably originally a gabbro or a diabase. It appears to be a rock much like No. 5, but in a much more advanced stage of alteration. There is now no trace of its original structure nor of its original pyroxene. It is a confused aggregate of brown biotite, in rather sharp crystals, somewhat changed to chlorite, green hornblende fibres, epidote, quartz, calcite and sericite. The hornblende has, in all probability, resulted from the uralitization of pyroxene. The felspar of the original rock has also completely disappeared, and is now replaced by the micaceous mineral (sericite) and calcite. The quartz is all secondary, as is also the epidote and a little chlorite. In this confused mass are still numerous needles of apatite, which have survived all the alterations. Small grains of ilmenite, surrounded by leucoxene rims, are also present.

Rocks quite like this have been studied in many regions, where they can be traced with certainty into basic eruptives of normal character, and it is not impossible that specimens might be collected at this locality which would establish positively both the original form and the course of alteration of the present specimen.

No. 11. *Coarse-grained Granite*.—Lake Temiscaming, west side, one mile south of Crow's Nest Rock.

Macroscopically a coarse aggregate of grey quartz, reddish felspar and a pale yellowish alteration product.

The microscope shows a typically granitic structure, with orthoclase and microcline and a little striated plagioclase, and quartz. The rock is considerably altered, the felspar being opaque from this cause. The micaceous constituent, once present, has wholly disappeared, and is now replaced by a pale greenish-yellow sericite, containing iron in the form of magnetite. It also contains some sharp yellow needles (probably rutile). There has also been considerable potash mica (muscovite) developed at the expense of the orthoclase. There are further present in this granite as accessory constituents: zircon, in sharply defined reddish crystals; sphene, greatly altered; and a small amount of apatite.

No. 12. *Arkose Sandstone or Greywacke*.—South side Little River, Lake Temiscaming.

A dark grey, even and fine grained rock.

The microscope shows this to be composed of more or less rounded grains of granitic minerals—quartz, orthoclase, microcline and oligoclase—cemented by proportionately little sericite and chloritic material. The grains are all of the same average diameter, and plainly show by their character their derivation from granite while they appear to have suffered but little abrasion by running water. The dark color of this rock is largely due to the great amount of chlorite in its cement.

No. 13. *Quartzite Grit*.—High Pond, Maple Mountain, west of Lady Evelyn Lake and south of Montreal River.

This is a pale yellow rock, resembling a quartzite, but with distinct and more or less rounded, pebbles which in appearance closely resemble their matrix. Sericite is also abundantly visible to the unaided eye.

The microscope shows this rock to be composed of angular or but slightly rounded grains of granitic quartz, full of fluid inclusions, which are imbedded in a ground-mass of sericite and finer quartz fragments. These quartz grains or fragments differ greatly in size, but are under a millimeter in diameter. Felspar substance is now rare. It, however, was once present, but under the influence of dynamic action, it seems to have passed into sericite or muscovite. In a matrix of this character, medium sized pebbles are imbedded. These differ from the matrix principally in having a more silicious ground-mass, *i.e.*, they are freer from the sericite. They are, however, coated by a membrane of sericite, as is apt to be the case with squeezed conglomerates or grits. The rock shows distinct evidences of the action of pressure, and the development of its mica is probably due to this agency. A large fragment of the reddish zircon, like that in slides 8 and 11, was also observed in this section.

No. 14. *Greywacke*. 455½ miles west of Montreal, on the main line of the Canadian Pacific Railway.

A dark-bluish grey rock in which minute quartz fragments and grains are very apparent to the unaided eye.

Under the microscope numerous angular or somewhat rounded grains of granitic quartz of various sizes appear, imbedded in a finer aggregate of felspar, quartz, chlorite and mica. The dark color of the rock is due to minute dust-like inclusions of an opaque substance which crowd the felspar grains. They seem generally to be developed along cleavage cracks and appear to be of secondary origin, as they sometimes cover the whole felspar grain so as to make it almost opaque, and at other times are developed only in certain parts of the grain. The felspar substance is furthermore somewhat changed to mica and considerable chlorite is also developed. Reddish zircon and a little brown tourmaline are also found in this rock. The black opaque substance of this rock is not carbon, as it cannot be burned away by heating. It is some oxide of iron not easily dissolved by hydrochloric acid as is magnetite. By heating it is reddened, and may be ilmenite. See Figure 4.

FIGURE 4.



Section of specimen 14, from the main line of the Canadian Pacific Railway, 455½ miles west of Montreal. Greywacke, showing grains of quartz embedded in a finer aggregate of felspar, quartz, chlorite and mica.

No. 15. *Felsite or Microgranite*.—North side of Copper Cliff mine. A light colored evenly granular rock, containing very occasional black spots.

Under the microscope this is an aggregate of interlocking quartz and felspar grains with almost no trace of a ferro-magnesian constituent. Only minute needles and flakes of green hornblende are very sparsely disseminated, and these may make up the black spots visible in the hand specimen, though none of these were intersected by the thin section. The felspar is mostly orthoclase, with a little microcline and oligoclase. It is slightly kaolinized. Minute crystals of zircon are also rarely visible. There is nothing in the structure of this rock to indicate its clastic origin, although it is not impossible that it may be a recrystallized arkose. The constituents, especially the quartz, indicate by their undulatory extinction the action of pressure. (This rock may be compared with Nos. 2, 3 and 4.)

No. 16. *Microgranite or Felsite*.—South part of Lady Evelyn Lake. A fine compact pale grey rock, dotted with minute green specks.

The microscope shows this specimen to be an extremely even aggregate of quartz and felspar grains, containing disseminated areas of chlorite. The separate grains are noticeable for having almost exactly the same shape and size throughout the rock ; still they form an interlocking mosaic and appear to have originated *in situ*. The felspar is mostly orthoclase, and the structure is typically that of a microgranite. No porphyritic crystals whatever are discernable. The ferro-magnesian silicate is wholly replaced by chlorite. It is not impossible that this rock may have been derived from the consolidation and recrystallization of an arkose. Its structure is not conclusive on this point.

No. 17. *White Sandstone*.—Log rollway, four miles north-east of inlet of Echo Lake.

This rock looks like a white and slightly felspathic quartzite, but its clastic character is apparent upon closer examination, even without the aid of the microscope.

The section of this specimen appears under the microscope to be a mass of variously shaped, but mostly rounded quartz grains. There is but very little true cement, but the quartz grains have undergone enlargement by the deposition of interstitial silica so that they frequently interlock by irregular sutures. This silica is optically continuous with the quartz grain which it surrounds, as described by Irving and Van Hise. (U. S. G. S., Bull. No. 8.) There is also some felspathic substance present in this rock which is considerably kaolinized. Rutile in deep yellow grains and crystals is also quite abundant, while the quartz encloses occasional zircon crystals.

No. 18. *Fine-grained Arkose or Greywacke*.—East side of Upper Wahnapitae River, 13 miles north of mouth.

Compact, greenish-grey vitreous-looking rock, resembling a felsite.

The microscope shows small angular fragments of quartz with a little kaolinized felspar, distributed through an abundant sericite matrix. This has mostly resulted from the alteration of felspar substance, although it is mixed with some smaller quartz grains. The clastic origin of this rock is beyond a doubt.

No. 19. *Microgranite or Felsite*.—Foot of first portage below Rabbit Lake (between Lake Temagami and the foot of Lake Temiscaming.)

Compact brown felsitic rock.

The microscope shows this specimen to be comparable with No. 16 from Lady Evelyn Lake. It is an even grained mosaic of quartz and felspar; the latter mineral (on account of the thickness of the section) being reddish and nearly opaque. The place of the ferro-magnesian constituent is now occupied by chlorite. Crystals of magnetite, which are sometimes accompanied by yellow rutile needles, occur near the chlorite. The shape of the grains in this specimen suggests, even more strongly than in the case of No. 16, a possible clastic origin.

No. 20. *Coarse conglomeratic Sandstone or Greywacke*.—Five miles north-east of inlet of Echo Lake.

Variagated rock of uneven coarse grain, containing good sized pebbles of white quartz.

The thin section of this specimen shows both rounded and angular quartz grains of very variable size imbedded in a moderately abundant sericitic matrix. Its appearance is closely like that of slide No. 9 from Maple Mountain. The quartz grains and pebbles exhibit the influence of pressure, many of them having an undulatory extinction and not infrequently being broken and displaced in the matrix.

No. 21. *Conglomerate (or Agglonerate?)*.—Outlet of Lake Maskinongéwagaming.

Large rounded pebbles of a granular mottled rock in a black compact matrix.

The microscopic section of this specimen shows both kinds of rock and the contact-line between them. The pebbles are extremely altered, rather coarse grained diabase (dolerite). The structure of this rock is still sufficiently preserved to make its nature and origin certain, although its original mineral constituents are now entirely altered. Its lath-shaped felspar crystals have decomposed to a semi-opaque grey saussuritic mass, while its augite is now replaced by chlorite of a pale green color. Even its ilmenite has wholly disappeared, as such, but it has left an unmistakable record behind in the characteristic skeleton forms produced by the rhombohedral parting, and now composed of dark grey leucoxene which has resulted from its alteration. Pyrite is also present in this altered diabase. The matrix of this rock is unmistakably clastic

in its character. Small angular and slightly rounded quartz grains with some felspar, are enclosed in a chloritic base, containing brightly polarizing sericite or kaolin.

No. 22. *Arkose Sandstone*.—Montreal River, four miles above Temagami Branch.

A reddish grey granular rock of medium even grain.

The microscope shows this to be an even grained mixture of somewhat rounded quartz grains with an equal amount of felspar (orthoclase, microcline and oligoclase). The minerals and their proportions are those of a granite, and yet the appearance of the grains and their relations to one another at once disclose the clastic character of the rock. The felspar, except a few of the largest grains, is quite changed to kaolin or sericite, although its external characters are still plainly discernable. This renders this specimen of peculiar interest in showing the origin of rocks like Nos. 9 and 20, whose sericitic matrix has, in all probability, passed through a similar stage in its development out of the felspar substance.

No. 23. *Biotite-epidote Gneiss (or Gneiss-conglomerate)*.—Three quarters of a mile north-west of Copper Cliff mine.

This small specimen consists of two distinct portions: a dark, fine grained, micaceous rock, and a light felspathic one. The true relations of these two portions cannot be made out from the material at hand. The latter rock may be a nest or "eye" secretion such as are frequent in the gneissic rocks; or it may be a pebble. The extreme sharpness of the contact between the two portions points rather to the latter hypothesis.

As seen under the microscope, both portions of this specimen are gneisses. The darker portion, of which there is but very little in this section, is a fine grained aggregate, consisting mostly of biotite and epidote (or zoisite) with both felspar and quartz. The mica and epidote have certainly crystallized *in situ*, but they surround small transparent areas of quartz or felspar which look as though they might represent former fragments.

The lighter portion of the specimen is a felspathic gneiss, of uneven grain. It contains comparatively small amounts of the same biotite and epidote occurring in the darker portion, which have here also crystallized in their present position. No part of this rock now shows an undoubtedly clastic structure. If it was ever a sedimentary deposit, it has undergone very extensive recrystallization since its consolidation.

No. 24. *Banded coarse and fine conglomeratic Sandstone or Grey-wacke*.—South-west side of Bay Lake, Montreal River.

A portion of this specimen is quite like No. 20, but this alternates with much finer grained layers, which alone are represented in the thin section.

The section shows an aggregate of angular and subangular quartz grains with some felspar. Between these grains much chlorite has been developed, which, together with the magnetite present, gives the dark color to this layer.

No. 25. *Arkose Sandstone*.—North-east side of mountain, near Wendabin's house, Lady Evelyn Lake.

A reddish white rock of medium grain, which closely resembles a granite in macroscopic appearance.

Under the microscope the clastic nature of this rock is at once apparent, especially when it is viewed with a low power between crossed Nicol prisms. The grain varies considerably in its coarseness in different parts of the section. Quartz, orthoclase and plagioclase fragments are thickly crowded and connected by comparatively little sericitic matrix. This can, however, be seen to be forming at the expense of the felspar substance. There has been some enlargement of the grains by subsequent growth, so that, in spite of their clastic character, they often interlock with irregular sutures.

No. 26. *Dark fine-grained Biotite Gneiss*. (Extremely metamorphosed clastic).—Railway track, 1 mile south of the Stobie mine.

A dark-colored compact rock, which gives in the hand specimen but little clue to its true character.

Under the microscope this rock appears as a fine-grained mixture of biotite and quartz, to which a small proportion of felspar is added. The mica has evidently crystallized *in situ*, and exhibits a decided parallelism in the position of its flakes. This produces a somewhat indistinct gneissic structure, which is hardly observable at all in the hand specimen. Moreover, the mica is not evenly distributed through the rock, but is concentrated in bands which surround oval or lenticular areas. These are always elongated in the direction of gneissic structure and are composed of quartz, with occasionally a little felspar. The material which composes these elongated areas differs extremely in the coarseness of its grain, and appears to have been entirely recrystallized, although the form and distribution of the areas strongly suggest their being former pebbles. The only other constituent observed in this specimen consists of minute highly refractive granules surrounding grains of iron ore. They are the variety of sphene known as leucoxene.

My interpretation of this rock is that it was once a clastic grey-wacke, like many of the others represented in this collection, but that

it has subsequently undergone such complete metamorphism that a large amount of biotite was developed anew in it, while most of the quartz was recrystallized. These extensive changes have, however, gone on without entirely obliterating the original clastic structure of the rock.

No. 27. *Metamorphosed Greywacke Conglomerate*.—Two hundred yards east of Copper Cliff mine.

This is a pale pinkish, felsitic rock in which large and small irregularly shaped pebbles are very faintly traceable in a matrix that differs from them in external appearance only in being slightly darker.

The contrast between pebbles and matrix is much stronger under the microscope than it is in the hand specimen. The former (the pebbles) are composed of a granular aggregate of quartz and felspar, the latter being in proportionately small amount; while the matrix consists mostly of quartz and epidote. The latter mineral is in very minute highly refractive granules which are crowded into a nearly opaque mass until they are resolved by a high magnifying power. This epidote has originated in its present position as a result of metamorphism. The pebbles themselves also show the effect of metamorphism by dynamic action, being pressed and distorted in shape, as well as frequently broken and their fragments more or less displaced.

No. 28. *Felspathic Sandstone or Quartzite with large quartz pebbles(?)*.—Lake Wahnapitæ Gold mine.

A vitreous white quartzite full of reddish felspar grains and containing large areas of pure white quartz, whose nature cannot be made out from this specimen.

The section, which is from the finer grained portion of this rock, shows under the microscope an appearance like that of No. 22. Angular or sub-angular quartz grains that have undergone some secondary enlargement, are mingled with felspar which is changing, though it has not yet entirely changed to a sericitic ground-mass.

No. 29. *A dark greenish-grey cryptocrystalline rock*.—Island in Lady Evelyn Lake.

This is a light colored felspathic sandstone, with an abundant sericitic-ground mass or matrix, much like the last described specimen, except that there has been no enlargement of the quartz grains to speak of.

No. 30. *Sericitic Chlorite Schist*.—The smelter, Copper Cliff mine near Sudbury.

A dark grey compact rock with small whitish blotches, and a quite distinct cleavage caused by the parallelism of the mica flakes.

This specimen, which was probably once a clastic, has undergone extreme metamorphism, whereby most of its original characters have

been obliterated. It is now a fine grained aggregate of quartz and sericite, with which is associated considerable pale green chlorite and a minute quantity of opaque iron oxide. The sericite and chlorite have a distinct parallelism in arrangement, producing a cleavage. Within this uniform mass, which makes up by far the larger portion of the section, are irregular and ill-defined areas much richer in quartz. These correspond to the lighter colored blotches in the specimen and may represent former pebbles which have been recrystallized and well nigh obliterated by the metamorphism. A small vein of quartz passes two-thirds of the way across the section and terminates within it. The indications are that the chlorite of this rock has been derived from biotite, and its sericite from felspar, although neither of these original constituents is now present.

No. 31. *Fine-grained Hornblende Biotite Granite*.—Ridge three quarters of a mile west of Stobie mine.

It is of course impossible for me to tell whether this rock may not possess in the field a parallel structure which would entitle it to be called a gneiss, but as far as this small specimen is concerned its structure is typically granitic.†

The constituents of this rock are quartz, orthoclase, microcline, oligoclase, biotite, hornblende, zircon, magnetite and epidote. The structure of this rock is typically granitic, but it shows a decided evidence of the action of pressure both in the disturbed optical behavior of the felspar, and in the peripheral granulation (Germ. Randsliche Kataklase) produced by a rubbing of the grains against each other. (cf. Rosenbusch : Mass. Gest. 2nd. Ed., p. 42.) The ferro-magnesian components are not evenly distributed through the rock, but are aggregated in groups which consist mostly of hornblende and biotite, along with considerable reddish zircon. There is also scattered generally through the rock a small quantity of biotite. The latter mineral is of secondary origin. The opaque iron oxide of this rock resembles magnetite, but it is probably titaniferous, as each grain is surrounded by a highly refractive transparent border, which has all the properties of leucoxene (titanite).

No. 32. *Fine-grained Diorite*.—Country-rock of the ridge just west of Stobie mine.

A fine-grained dark hornblendic rock, without any foliation visible in the small hand specimen.

The microscope shows this rock to be a fine evenly granular aggregate of felspar, hornblende, biotite and magnetite, which is practically

† No indication of foliation was observed at this locality. The rock is extensively exposed and is all massive.—R. BELL.

free from quartz. The felspar is for the most part unstriated (which indicates, but does not prove, that it is orthoclase). If analysis should show that orthoclase were much the more abundant felspar, the rock would be more properly termed a syenite. The general character of the rock is, however, rather that of a diorite. Hornblende of the usual green variety, rarely with well-defined crystal form, is abundant. Associated with this is considerable biotite. The opaque iron oxide is surrounded by leucoxene borders. Apatite needles abound in the felspar, and quartz is only sporadically present. The structure of the rock, as seen in the section, is granular, and it is not impossible that it may have originated from the metamorphism of a basic eruptive containing pyroxene, although no trace of this mineral is now present. The specimen is comparable with No. 5 (the rock immediately associated in the ore of the Copper Cliff mine) without, however, there being here the certain proof of derivation that there exists.

No. 33. *Recrystallized Sandstone*.—The Hill, Sudbury Village.

A light grey, distinctly elastic though fine-grained rock. It has no pronounced cleavage in the hand specimen, but is somewhat evenly jointed.

The microscope shows this to be a fragmental rock composed mainly of quartz, in which considerable recrystallization has gone on. Good sized and quite irregularly shaped quartz grains are imbedded in a fine-grained mass, which also consists in large part of quartz mingled with some felspar substance. The quartz frequently shows the optical disturbance which is indicative of the action of pressure, and the interlocking of the grains proves that there has been considerable growth or enlargement since deposition. Chlorite has been extensively developed in the matrix of this rock. The only other minerals noticed were magnetite in minute specks and an occasional grain of zircon. A quartz vein of small dimensions crosses the thin section.

No. 34. *Garnetiferous Hornblende Biotite "Augen" Gneiss*.—West line of the township of Hyman, one mile north of Spanish River.

This is a normal gneiss, much "stretched," whose darker and finer grained portion bends around elongated lenses or "eyes," composed essentially of quartz. Minute crystals of red garnet are abundant, particularly around the edges of the quartz lenses.

The microscope shows the lenses or "eyes" of this specimen to be composed almost exclusively of large interlocking quartz grains, which bear witness by their undulatory extinction to the action of great pressure. The mass of the rock which encloses these lenticular areas is an aggregate of felspar (both orthoclase and plagioclase) quartz, biotite, hornblende, garnet, and iron oxide. The felspar, quartz and

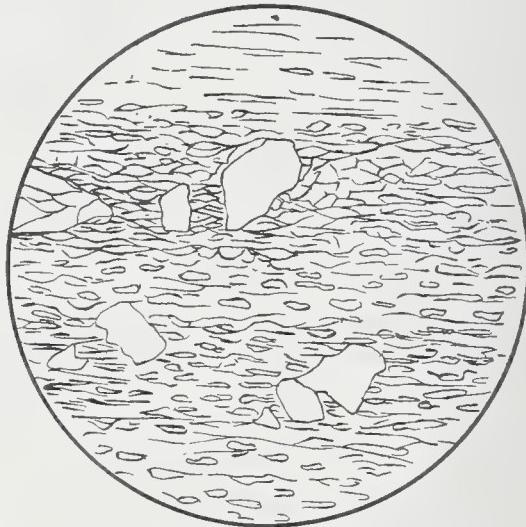
biotite present no peculiarities worthy of note. The hornblende is intensely trichroic, as follows: a pale yellow; b very dark yellowish-green; c dark bluish-green; absorption: $c > b > a$. It occurs in irregular patches or in prismatic crystalloids, associated with the biotite in matted aggregates. It has evidently originated *in situ*. The garnet is in good sized grains or imperfect dodecahedral crystals in the matrix of the rock. It also occurs in very minute, but very imperfect dodecahedrons in the quartz of the "eyes."

The structure of this rock is granular as far as its quartz and felspar are concerned, and shows the effect of pressure in the crushing of its grains. The interlacing or membranous (Germ., *flaserig*) structure characteristic of a gneiss is imparted altogether by the arrangement of its mica and hornblende. The recrystallization of all the components of this rock has been so complete that it can now only be spoken of as a gneiss. There is nothing in its structure to indicate whether it has been produced by dynamic metamorphism from a clastic arkose, from an eruptive granite, or whether it has always possessed the characters which it now exhibits.

No. 35. Same as No. 42., *q. v*

No. 36. *Stretched Quartzite*—Three miles and a-half up the West Branch of Spanish River.

FIGURE 5.



Section of specimen 36, from three miles and a-half up the west branch of Spanish River. Stretched quartzite, showing the larger grains of quartz pulled apart in the direction of the stretching.

This is a pinkish to brownish, cryptocrystalline banded rock, which might be macroscopically designated as a banded jasper or felsite.

The microscope shows that it is a clastic, consisting of quartz which has been almost wholly recrystallized under the influence of intense pressure, and that it has thus had the parallel structure developed in it by an elongation of its grains in one direction, that is commonly known as "stretched" (Germ., *gestreckte*) structure.

During this recrystallization there has been a large amount of epidote developed in this rock, which appears as extremely minute granules. Felspar substance is also present in amounts which vary very much in different parts of the specimen, being most abundant in the pinkish bands. An occasional needle of hornblende may also be seen. That there has been an actual stretching of this rock during its recrystallization is proved by the fact that the larger quartz grains, which have retained their original individuality, have been broken and their fragments pulled apart, always in the direction of the banding. This may be seen from the accompanying sketch, Figure 5.

No. 37. *Extremely altered Gabbro or Diabase (?)*—Vermilion mine, shaft No. 2, Denison.

A pale grey compact even-grained rock, rich in pyrite.*

This rock now appears under the microscope as a confused mass of chlorite, biotite, epidote, sericite, quartz, pyrite, opaque iron oxide, leucoxene, calcite and apatite needles. All of these minerals except the apatite are of secondary origin, and with their production the original structure of the rock has been quite obliterated. This specimen is comparable with No. 10 from the same locality, of which it seems to represent a much more altered form.

It is of course impossible to say in such an altered rock what its original form was, but there is little doubt that it represents the remains of some basic eruptive (either diabase or gabbro). From analogy with Nos. 5 and 10 we may say that the choice is perhaps in favor of gabbro. The pyroxene of the original rock has given rise to the chlorite and biotite; the felspar, to the sericite, calcite and quartz. The iron oxide (ilmenite or titaniferous magnetite) is partly changed to sphene (leucoxene), while the apatite needles alone remain in their original form.

No. 38. Rock from Nachvak, Labrador. *See end of list.*

No. 39. Rock from Ottawa Islet, Hudson Bay. *See end of list.*

No. 40. *Amphibolite or Hornblende Schist*.—Murray mine.

A fine-grained very dark green or nearly black foliated rock, containing a much coarser felspathic or granitic vein.

This is a closely interwoven aggregate of green hornblende and brown biotite. The foliation is produced by the approximate parallel-

*The pyrite is thickly scattered through the rock in very fine grains.—R. B.

ism in the cleavage directions of these minerals. The only other constituents visible under the microscope are quartz, and ilmenite surrounded by veins of sphene (leucoxene). Of the origin of this rock we can say nothing now with certainty. It may well have resulted from the extreme metamorphism of some basic eruptive, but from a small specimen like this it is unsafe to draw any such conclusion. The felspathic vein is a much coarser aggregate of quartz, orthoclase and plagioclase with a little green hornblende. The felspar has many minute hornblende needles secondarily developed in it, but otherwise the rock appears like a fresh granite.

No. 41. *Recrystallized Arkose*.—Quarter of a mile north-west of Copper Cliff mine.

A grey rock enclosing large and small fragments of a highly felspathic granite or coarse gneiss.

The microscope shows plainly the clastic nature of this rock, in spite of the fact that extensive recrystallization has gone on in its matrix. This is a mixture of minute quartz and felspar grains, in which biotite and epidote have been extensively developed *in situ*. Some of the smaller areas included in this matrix seem to have been entirely recrystallized and now consist of an interlocking mosaic of limpid striated felspar (albite) and quartz grains. The largest fragments in this rock have, as far as can be determined by the microscope, the normal structure and composition of a hornblende-biotite granite.

Nos. 35 and 42. *Vitrophyre Tuff**.—Lowest falls of the Onaping River.

This dark compact rock is crowded with lighter-colored patches, which at first glance seem to resemble porphyritic crystals. A closer examination, however, shows that they possess extremely irregular outlines which are inconsistent with such an hypothesis.

Under the microscope the real character of this unusual rock is at once apparent. It consists of volcanic ejectamenta in the form of glass fragments of all shapes and sizes, associated with some crystals or crystal fragments (Fig 6). Some of the glass is, or was, a pumice, although most of it was compact, and exhibits in a beautiful manner the fluidal structure often observable in recent acid glasses. These sharply angular fragments grade down to those of microscopic dimensions, and all are imbedded in a dark matrix consisting of still finer fragments of a globulitic glass. This specimen is therefore a consolidated volcanic ash in which a great amount of chemical change (mainly silicification) has gone on without materially disguising the

* This rock has been mentioned by Prof. Bonney in his paper on the Sudbury rocks. (*l. c.* p. 40.)

original form of the rock. In spite of the rock having once been principally composed of glass it now contains none of this material. It has been replaced almost entirely by finely crystalline chalcedonic quartz. The cavities in the pumice have been filled with the same substance. Some of the crystals are rounded grains of limpid quartz without any impurity or composite character. In one of the specimens there is a large crystal of fresh felspar, presenting glistening cleavage surfaces, but this mineral is exceptional and does not appear in either of the thin sections.

In an appendix to a paper by Dr. Bell, read before the Geological Society of America, 31st December, 1890, the present writer says: "In a hand specimen this rock presents a nearly black felsitic matrix, in which are embedded sharply angular or slightly rounded fragments, varying from $1\frac{1}{2}$ cm. in diameter downwards to ultra-microscopic dimensions. These fragments are lighter in color than the matrix, but differ considerably among themselves in their tint, structure and composition. The majority resemble chalcedony in appearance, others are greenish, while some of the largest fragments are now replaced by a single calcite individual. Occasional small grains of clear vitreous quartz may also be detected, while specks of magnetic pyrites (pyrrhotite) are everywhere abundant. Many of the angular fragments show distinctly under the lens a flow or vesicular structure, which is still more apparent in a thin section of the rock when seen under the microscope.

FIGURE 6.



Section of silicified Glass-Breccia or Vitrophyre Tuff. No. 42.

"The appearance of this rock when viewed with a low magnifying power ($\times 20$ diameters) is shown in the accompanying figure 6, for which I am indebted to the skill of Mr. Charles R. Keyes, Fellow in Geology at the Johns Hopkins University.

"The fragments, even down to those of the smallest dimensions, have the angular form characteristic of glass sherds produced by explosive eruptions. The larger fragment in the lower part of the figure is finely vesicular, while the one above is more coarsely so. The flow structure is as perfectly marked by sinuous lines of globulites and microlites, which terminate abruptly against the broken edge of the glass particle, as in the most recent vitrophyre. Minute spots of opaque pyrrhotite are scattered throughout the section. The ground-mass is of a dark color, owing to the massing in it of minute black globulites, to whose nature the highest magnifying power gives no clue.

"Unfortunately, no* analysis of this interesting rock has as yet been made. Between crossed Nicols it is seen to be made up largely of chalcedonic quartz, which has changed the easily destructible glass into a sort of jasper. Chlorite is also abundant, frequently arranged as a border of radiating scales around the edges of the fragments, so as to coat them green in the hand specimen. The larger grains are always a fine mosaic of interlocking quartz, but some of the smaller ones are composed of a unit individual of clear vitreous quartz. The only other minerals which could be identified in the section are calcite and a few grains of a glassy, striated feldspar. The presence of this latter mineral is very noteworthy, as we should expect it to have disappeared during the vicissitudes through which this rock has passed.

"After a careful study of this rock I find it possible only to interpret it as a remarkable instance of a very ancient volcanic glass-breccia, preserved through the lucky accident of silicification. Nor did this process go on, as is usual, through devitrification and loss of structure, but rather like the gradual replacement of many silicified woods, whose every minute detail of structure is preserved. The rarity of such rocks in the earth's oldest formations is readily intelligible, but for this very reason the exceptional preservation of a rock like this is all the more welcome proof that explosive volcanic activity took place at the surface, then as now, and on a scale, if possible, even greater than that with which we are familiar."

No. 43. Rock from near Skynner's Cove, Nachvak, Labrador. See end of list.

*Since the above was written, Mr. Hoffmann has made an analysis of a specimen of this rock from the High Falls of Onaping River and found it to contain 60.23 per cent. of silica.

No. 44. *Garnetiferous Hornblende Schist*.—Vermilion mine. Road-side, one-third of a mile south-west of boarding house.

A fine-grained dark green hornblende schist, acting as the matrix for huge rounded crystals of reddish garnet, two inches or less in diameter.

The thin section of this specimen shows little except the garnet. This is quite normal, being reddish in color and isotropic in optical behavior. It is much cracked and slightly seamed with green chlorite which has resulted from its incipient alteration. It is also stained with iron hydroxide, and contains numerous inclusions of magnetite and quartz.

There is a very little of the hornblende schist also included in this section. It is an irregular aggregate of short and stout hornblende fibres mingled with more or less quartz.

No. 45. *Crushed and re-crystallized Granite*.—Canadian Pacific Railway, south-east of Murray mine.

Pale grey granitic rock.

This rock appears, under the microscope, like a granite which has been subjected to great crushing action. Its constituents are quartz, orthoclase, plagioclase, biotite, very little green hornblende, magnetite and zircon. The structure is irregular, the grains being of very unequal size with considerable fine mosaic. They, however, all interlock and appear to have been much broken by a crushing action. Many large felspar grains are fractured and the fragments separated. They are also granulated into a fine-grained mosaic around their edges. It is not possible to assert positively that this rock is not a wholly recrystallized arkose, composed of granitic debris, but there is now nothing in its composition or structure to indicate a clastic origin.

No. 46. *Quartz Hypersthene Gabbro with accessory Biotite*. Dyke, Dominion mine, township of Blezard.

A medium-grained massive brown trap, quite full of mica.

The microscope shows this to be an eruptive rock of quite exceptional character and interest. It belongs to the general type of gabbros, but has traces of a diabase-like structure in its long idiomorphic felspars; is related to the norites by the abundance of its hypersthene, and contains what is exceptional for all of these rock types—an abundance of original quartz. The rock is quite fresh, but shows the effect of dynamic action in the bending of felspar crystals and in the uralitization of the pyroxene.

The felspar is in stout lath-shaped crystals of good size, which produce a coarse ophitic or diabasic structure, as in many of the well known Scandinavian gabbros. They present a brownish color in the thin section, from an abundance of ultra-microscopic dust-like inclusions. They exhibit, in a beautiful manner, the effect of strain, in the bending

of the crystals and the production of secondary twinning lamellæ, similar to those described and figured by the writer from the Norites of the Cortlandt Series, near Peekskill, N. Y. (Am. Jour. Sci. (III) 33, p. 140, Feb., 1887.)

The pyroxene is both monoclinic (diallage) and orthorhombic (hypersthene) in about equal amounts. Both are undergoing alteration into compact green hornblende. The mica is an intensely pleochroic biotite. It is abundantly present in large flakes of irregular size and has all the properties of an original constituent. Quartz is also quite abundant in large clear grains of irregular shape, and was apparently the last mineral to crystallize. Apatite, zircon and magnetite are also present in considerable amount. This rock, although a typical gabbro, is unusually acid, and approaches in its quartz and zircon to the augite granites.

No. 47. *Granite (Micropegmatite)*.—Eagle Rock Lake ("Moose Lake"), near west end; township of Levack.

A dark rock of medium grain with reddish felspar.

The microscope shows this to be a biotite granite or granitite whose quartz and felspar are minutely intergrown as they are in graphic granite, thus producing the structure called micropegmatite or granophyre. This structure exists in this specimen in an unusual degree of perfection. It composes most of the rock-mass, and is usually developed as a delicate network surrounding and radiating from a central rectangular orthoclase crystal (generally a Carlsbad twin). The quartz exists for the most part intergrown with the felspar, but a few separate and individual grains may also be found. The ferro-magnesian silicate is biotite, now considerably altered. A little light green hornblende is also present, but this, like the chlorite, seems to be of secondary origin. Apatite is abundant in sharp acicular crystals, some of which have attained an extraordinary length.

No. 48. *Olivine Diabase*.—Great Dyke, 5th Portage, Spanish River.

A medium grained grey rock whose diabase structure is macroscopically apparent.

The microscope shows this specimen to be a fresh aggregate of olivine, reddish augite, plagioclase and ilmenite, with accessory apatite and biotite. Its diabase or ophitic structure is very typical. The olivine in this rock is remarkably fresh. It is in small pale yellow grains, which rarely show external crystal boundaries. It has a very high refractive index, no pleochroism, and contains glass inclusions. The augite is of the reddish and slightly pleochroic variety common in diabase. It not uncommonly shows zones of growth, having different shades of color. In form the augite is allotriomorphic, filling the interstices between the laths of plagioclase. The felspar (probably

labradorite) is idiomorphic and forms an interlacing network of lath-shaped crystals. It is the only constituent that shows any alteration, and this is comparatively slight. The opaque iron oxide is probably ilmenite. It is without distinctive form or alteration, and is sometimes surrounded by a narrow rim of biotite. Apatite is abundant.

No. 49. *Diabase*.—Bruce Mines, north shore of Lake Huron.

A dark brown granular rock, containing vein quartz and disseminated chalcopyrite.

The microscope shows this specimen to be a diabase, free from olivine and in rather an advanced stage of alteration. Its structure is quite normal. The stout and somewhat rounded laths of plagioclase are but little altered. The place of the pyroxene, on the other hand, is entirely taken by a granular aggregate of brownish crystalloids with a weak double refraction and high extinction. These may represent originally polysomatic augite (cf. Lawson, Rainy Lake Report), but they now occupy areas of the irregular form characteristic of diabase pyroxene. The common change of the pyroxene to hornblende or chlorite has hardly more than commenced in this rock. There is little secondary quartz present.

No. 50. *Felsite*.—Cliff on Colonization Road, half a mile north-west of Sudbury.

Pale grey compact felsite.

The microscope shows this rock to be a medium grained mosaic of interlocking quartz and felspar individuals, with which are associated a small amount of biotite, magnetite and minute highly refractive epidote (?) granules. All the constituents are quite fresh, although the felspar shows an incipient stage of kaolinization. The grain is not entirely even, nor are there any distinctly porphyritic crystals present. It is not impossible that the rock may be of clastic origin, but if it is, recrystallization has progressed so far as to obliterate all certain traces of its original structure.

No. 38. *Porphyritic Diabase or Diabase-Porphyry*.—(Dyke) Nachvak, Labrador.

A dark green compact and massive rock, in which minute crystals may be detected with the unaided eye. One side of this specimen represents the edge of the dyke, and from this the grain can be distinctly seen to grow coarser as we pass to the opposite side of the specimen.

The microscope shows that, in spite of considerable alteration, the original composition and structure of this rock are still plainly recognizable. Good sized lath-shaped crystals, of an almost colorless augite, are imbedded in a fine-grained but holocrystalline ground-mass, composed of minute lath-shaped felspars and green hornblende. The

only other noticeable constituent is titanic iron (ilmenite) in minute-grains; which is largely altered to grey leucoxene.

The alteration to which this rock has been subjected, consists principally in uralitization of the pyroxene, *i.e.*, its change into more or less fibrous, secondary green hornblende. This change is only partial in the case of the larger porphyritic pyroxene crystals, so that a large core of unaltered mineral remains at the centre (Fig. 7). In the case

FIGURE 7.



Section of specimen 38, from a dyke at Nachvak, Labrador. Porphyritic diabase or diabase porphyrite, showing an unaltered core of pyroxene in a crystal which has been peripherally changed to hornblende.

of the finer pyroxene of the ground-mass, however, the change to hornblende has been complete. Accompanying this development of secondary hornblende, there has been some little biotite also formed. The felspar has itself suffered little alteration, although very delicate hornblende needles have also been developed in it. The opaque iron ore (ilmenite) is extremely changed to leucoxene, which surrounds it as a border, when the grain of the original mineral has not been entirely replaced. Twinning parallel to the orthopinacoid is a very common feature in the original augite of this rock.

No. 39. *Variolite (Spherulitic Diabase.)*—Ottawa Islet, Hudson Bay.

A compact greenish-grey rock, with round or oval spots of a paler color distributed somewhat irregularly through it.

The microscope shows this specimen to be, in spite of its greatly altered condition, a rock of unusual interest. It represents a peripheral facies of a diabase, called variolite (*cf.* Rosenbusch: Mass. Gest., 2nd Ed., p. 227), which, although well known from many localities in Europe, has not, as far as I am aware, ever yet been described from any part of America. This specimen came in all probability from near the edge of a mass of diabase, and was once a very fine grained (possibly partly glassy) and porphyritic variety of this rock. The round or oval spots represent former spherulites, which are characteristic of rocks

whose solidification has been rapid. Such spherulitic aggregations, while universally distributed through the acid rocks, are exceptional in those of basic composition. Nevertheless, they have been described from the edge of diabase areas in Bavaria, Saxony, Savoy, Piedmont, Russia and Great Britain.

This specimen of variolite from Hudson Bay has suffered total alteration of all its original mineral components, and yet enough of its original structure has been preserved to place its true character beyond reasonable doubt. The main mass of this rock is now a matted aggregate of secondary hornblende flakes and fibres, together with epidote, chlorite and a little quartz. There are, however, still recognizable traces of the former structure, for the narrow laths of felspar have frequently left their outlines where their substance has wholly disappeared. The outlines of the former porphyritic crystals are in the main quite sharp. From their shape they appear to have been largely olivine, although they are now all replaced by an aggregate of serpentine, chlorite and epidote. The oval patches of a lighter color appear in the thin section as cloudy and almost opaque areas. They are also composed largely of secondary hornblende, chlorite and epidote, but through them run the lighter, more or less radiating lines representing the former felspar crystals, whose arrangement is quite characteristic of the spherulites or "varioles" of the European varieties.

No. 43. *Hornblendic Pyroxenite*, in process of alteration to talc (steatite). Near Skynner's Cove, Nachvak, Labrador.

A dark massive rock of trappian aspect, but noticeably soft and easily scarred white by even a slight scratch.

This specimen is of very exceptional interest, both on account of its original petrographical character, and also because of its alteration, the process of which is admirably shown in the thin section. The rock was once an evenly granular aggregate of enstatite, diallage, hornblende and magnetite.* The first named of these constituents is by far the most abundant and it has succumbed to an extensive alteration into a finely matted aggregate of talc scales. This same alteration has also gone on, although to a much less extent in the hornblende and also to a still smaller extent in the diallage (Fig. 8). It is analogous to the alteration of the enstatite from Bamle, Norway, to talc, so fully figured and described by vom Rath and Brögger (Monatsber. Berl. Akad. Wiss., Oct., 1876, and Zeitschrift für Kryst. I. p. 18.)

The enstatite has very pale colors in the thin section, but has its characteristic pleochroism; a. reddish; b. yellowish to colorless; c.

* It is, therefore, a hornblendic variety of the rock-type for which the writer has suggested the name Websterite. Am. Geologist, July, 1890.

pale greenish. It also shows parallel extinction and all the other properties of an orthorhombic mineral, together with the rectangular cleavage of pyroxene in cross sections. It no longer has its original form, but now exists only as irregularly shaped cores in the midst of the talc which has taken its place.

FIGURE 8.



Section of specimen 43, from near Skynner's Cove, Nachvak, Labrador. Hornblendic pyroxenite in process of alteration to talc. *a.* Hypersthene or enstatite. *b.* Hornblende. *c.* Talc. *d.* Magnetite. *e.* Diallage.

The hornblende is next to the enstatite in abundance. It has all the properties of an original component. It is compact and with its usual optical orientation and pleochroism: *a.* and *b.* pale yellow; *c.* green. Its alteration to talc is as yet comparatively slight. The monoclinic pyroxene, recognized by its high extintive angle, is nearly colorless and devoid of all pleochroism. Its amount is relatively small and it is the best preserved of all the constituents. The opaque iron ore in this rock occupies a very prominent place. It is in irregular grains, sometimes of rounded form, and is either compact or porous. The magnet shows it to be magnetite. The talc scales are usually arranged radially about these grains. The rounded contours of the largest and least solid of the magnetite areas, suggest that they may represent a replacement of olivine, but no certain traces of this mineral now exist in this rock.

APPENDIX II.

LEVELS OF LAKES ABOVE THE SEA.

The following are the approximate elevations above the sea, of the more important lakes shown on the map accompanying this report. In the case of lakes lying close to the Canadian Pacific Railway, the levels have been ascertained by direct comparison with some point on the line, but where the distance was considerable, the altitude of the lake was determined by barometric readings relatively to the railway, except, that of Onaping Lake, which was derived from a comparison of the mean of twelve barometric readings with the average reading at the sea level in the same month. The heights of the lakes in the north-eastern part of the sheet are deduced from the observations of the late Mr. Alex. Murray and myself, checked by the level of the railway at Wahnapitæ station. The names of the lakes are given in alphabetical order.

	Feet above sea level.
Bannerman Lake.....	1,270
Barlow (near W. end of Lake Nipissing).....	650
Campbell do	645
Crooked or Crab (near Cartier Station).....	1,348
Elbow (in Township 45).....	678
Fairbank, or Washaigamog.....	867
Geneva.....	1,345
Koo-ka-gaming.....	879
Maskinongé-wagaming.....	800
Matta-gama-shing.....	866
Ma-zin-in-waning, or Vermilion.....	786
Murray (W. of Sturgeon River).....	774
Nipissing.....	639
Ni-ta-wa-gami or Whitewater.....	835
Onaping.....	1,417
Onaping, Lower Lake.....	1,410
Panache.....	772
Pogamasing.....	1,181
Ramsay.....	820
Red Deer.....	685
Round.....	780
Straight.....	1,335
Vermilion, or Ma-zin-in-waning.....	786
Wahnapitæ.....	845
Washaigamog, or Fairbank.....	867
Wash-ki-gamog	788
White-water, or Ni-ta-wa-gami.....	835
Windy, or Ma-ko-ping.....	1,060

List of Elevations on the Canadian Pacific Railway from a point Fifty-two (52) miles west of Callander, which is 343·9 miles from Montreal.

These elevations were obtained from the profiles of the Canadian Pacific Railway corrected by comparison with the recently perfected levels of the United States lake surveys, as published by Mr. L. Y. Schermerhorn in the American Journal of Science, April, 1887, and the level of Lake Nipissing, as ascertained by William Murdoch, C.E., for the Department of Railways and Canals, Canada. The mean level of Lake Huron is given as $518\frac{3}{10}$ feet above mean sea level, while the level of Lake Nipissing, according to Mr. Murdoch, is 639 feet. Assuming these elevations as correct, the height of Sudbury Junction was fixed at 840 feet by the mean of the levels as brought up from Lakes Huron and Nipissing.

MAIN LINE CANADIAN PACIFIC RAILWAY.

Miles West of Callander.	Eleva- tion above Sea.	Miles West of Callander.	Eleva- tion above Sea.	Miles West of Callander.	Eleva- tion above Sea.
52	653	87	784	120	960
53	655	88	812	121	996
54	657	89	812	122	1037
55	661	90	796	Onaping St.	1050
56	657	91	810		1075
57	657	Romford St.	835	124	1097
58	660		831	125	1145
59	671		853	126	1202
60	672		833	127	1219
61	675		838	128	1257
62	670		838	129	1292
63	668		882	130	1349
64	663		842	131	1360
65	664		840	132	1370
66	662		856	133	1351
67	662	Sudbury St.	100	Cartier St.	1356
68	662		906		1364
69	663		954		1345
70	665		976		1349
71	667		975		1359
72	670		949		1364
73	669		895		1364
74	670		871		1343
Markstay. Veuve River B'dge.	673		875		1289
	674		106		1258
75	693	107	879	141	1261
76	699	108	878	142	1292
77	714	Murray Mine. Chelmsford St.	109	Straight Lake St.	1340
78	729		110		1335
79	740		111		1336
80	766		112		1311
81	823		113		1259
82	847		114		1206
83	847		115		1202
84	818		116		1156
85	788		Bridge across Ver- million River. Larchwood St.	151	1150
86	777			152	1145
Wahnapietæ St. Bridge across Wah- napietæ River.	776			153	1144
	776	117		Pogamasing St.	1144
		118	867	154	1140
	776	119	884	155	1156

SAULT STE. MARIE BRANCH.

Miles West of Sudbury.	Eleva- tion above Sea.	Miles West of Sudbury.	Eleva- tion above Sea.	Miles West of Sudbury.	Eleva- tion above Sea.
Sudbury St.	840	17	777	35	690
1	834	18	794	36	646
2	829	Whitefish St.	791	37	620
3	828	19	785	Bridge across Span- ish River.	620
Copper Cliff St.	832	20	810	Stanley St.	669
4	836	21	822	41	669
5	848	22	803	42	663
6	857	23	795	43	663
7	848	24	761	44	682
8	843	Worthington St.	756	45	667
9	792	25	756	46	679
10	783	26	738	47	666
11	786	27	710	48	642
Naughton St.	786	28	685	Webbwood St.	643
12	779	29	705	49	622
13	787	30	671		646
14	775	31	700		
15	765	32	718		
16	770	Nelson St.	702		
Bridge across Ver- million River.	771	33	705		
		34	704		

APPENDIX III.

REPORT BY H. H. LYMAN, M.A., OF MONTREAL, ON LEPIDOPTERA COLLECTED BY DR. R. BELL IN THE COUNTRY NORTHWARD OF LAKE HURON.

These specimens were taken in different years by Dr. Bell and embrace seventy-three (73) species of the order. Most of them were unfortunately in poor condition, and hence several species could not be determined with certainty, while some of the specimens were quite undeterminable. Having been collected for the purpose of identification only, few of them were preserved in such a way as to be of value for museum purposes.

The species of most interest is *Cænonymphia Inornata*, Edw., described from the neighbourhood of Lake Winnipeg. This species was not previously known from so far east except that Mr. Wm. H. Edwards, from drawings by Gosse, believes that it occurs in Newfoundland. The form represented in this collection is a very dark one and was thought by Mr. Henry Edwards of New York, to be a new species, but Mr. W. H. Edwards, of Coalburgh, W. Va., pronounced it to be *Inornata*. The other species represented are chiefly those which might naturally be looked for in the Lake Huron region. One of them, however, *Thecla strigosa*, Harris, was not before known to occur so far north in this longitude, though, further west, it is said to have been taken as far north as Manitoba. One of the most interesting specimens is a hermaphrodite of *Argynnus Atlantis*, Edw., in which the right side is male and the left female. The abdomen is unfortunately in too poor a condition to admit of an examination of the genital organs.

For the determination of some of the specimens I am indebted to Mr. Wm. H. Edwards, Professor J. B. Smith, of New Jersey, and the Reverend Geo. D. Hulst, of Brooklyn, N.Y. The following is a list of the species with the localities and the dates of capture. The number of specimens taken at each place is indicated by the numbers in brackets. Where no number is given, one is to be understood.

- Pieris Protodice*, Bd.—Lec. Sault Ste. Marie, July 16th.
P. Oleracea, Harris. Sault Ste. Marie, La Cloche, Montreal River. June, July and August.
P. Rapæ, Linn. Lake Temiscaming. September.
Colias Philodice, Godt. Sault Ste. Marie, Lake Temagami, Lake Temiscaming, La Cloche, Sudbury. July, August and September.

- C. Interior*, Scudder. (4) Spanish River, Lake Temagami. August.
Danais Archippus, Fab. Georgian Bay. July.
Argynnис Cybele, Fab. (3) Georgian Bay, La Cloche. July and August.
A. Aphrodite, Fab. (3) Lake Temiscaming, (3) Spanish River, Montreal River. July and August.
A. Atlantis, Edw. Sault Ste. Marie. June, July and August. One specimen is a hermaphrodite.
A. Myrina, Cram. (4) Sault Ste. Marie. July and August.
A. Chariclea, Schneid. (4) Spanish River. July.
A. Bellona, Fab. Lake Temiscaming. July.
Phyciodes Nycteis, Doub.-Hew. (2). Sault Ste. Marie. July.
P. Tharos, Drury. (8) Sault Ste. Marie, Spanish River. July.
Grapta Faunus, Edw. Montreal River. (2) Lake Temagami. (4) Vermilion River. August and September.
G. Progne, Cram. Vermilion Lake. July.
Vanessa Antiopa, Linn. (2) Lake Temagami, Vermilion River. August and September.
Vanessa J. Album, Bd.-Lec. Lake Temagami. (3) Vermilion River. (4) Echo Lake (2) Montreal River. July, August and September.
V. Milberti, Godt. (3) Sault St. Marie. July.
Pyrameis Atalanta, Linn. (2) Sault Ste. Marie, July.
P. Cardui, Linn. (2) Sault Ste. Marit. July.
P. Huntera, Fab. Sault Ste. Marie. July.
Limenitis Arthemis, Drury. (2) Lake Temiscaming. July. (2) Sault Ste. Marie. June and July.
Neonympha Canthus, Bd.-Lec. Sault Ste. Marie. July.
Cænonympha Inornata, Edw. (4) Sault Ste. Marie. June 28th, July 8th.
Satyrus Nephele, Kirby. Georgian Bay. (2) La Cloche. August.
Thecla Strigosa, Harris. Wahnapitæ Lake. August 17th.
Chrysophanus Thoe, Bd.-Lec. Sault Ste. Marie. July.
C. Hypophleas, Bd. (2) Lake Temiscaming. Little Current. (3) Sault Ste. Marie. July, August and September.
Lycæna —? Sp. undeterminable. Sault Ste. Marie. June 28th.
Pamphila Peckius, Kirby. Sault Ste. Marie. June.
Pamphila —? Sp. undeterminable. Sault Ste. Marie. End of August.
P. Mystic, Edw. (2) Sault Ste. Marie. June and July.
P. Cerues, Bd.-Lec. (2) Sault Ste. Marie. July.
Nisoniades —? Sp. undeterminable. La Cloche. August.
Deilephila Lineata, F. (2) Michipicoten. August.

- Ctenucha Virginica*, Charp. Sault Ste. Marie. June 30th.
Lithosia Bicolor, Grote. Wahnapitæ River. August 16th.
Euphanessa Mendica, Walk. (2) Sault Ste. Marie. July.
Crocota—? Mattawa. July 14th.
C. Rubicundaria, Hubn. Sault Ste. Marie. July.
Arctia Saundersii, Grote. Georgian Bay. August.
A. Phyllira, Drury. Near Bruce Mines. August 6th.
Agrotis Normaniana, Grote. Mattawa, July.
A. Haruspica, Grote. Mattawa. July 14th.
A. Ypsilon, Rott. Sault Ste. Marie. July.
A. Saucia, Hubn. Sault Ste. Marie. June 14th.
Mamestra Vicina, Grote. Mattawa. July.
Scoliopteryx Libatrix, Linn. Lake Temiscaming. July.
Lithophane Pexata, Grote. Upper Ottawa River, September.
Aletia Argillacea, Hubn. (5) Upper Ottawa River. September.
Plusia Balluca, Gey. Mattawa. July.
P. Bimaculata, Steph. (2) Lake Temiscaming. July.
P. Mortuorum, Guen. (2) Montreal River. August 2nd.
P. Viridisignata, Grote. Montreal River, August 9th.
Heliothis Armiger, Hubn. Vermilion River. September.
Catocala Concumbens, Walk. Sault Ste. Marie. August.
Pseudaglossa Lubricalis, Gey. Mattawa. July 14th.
Epizeuxis Æmula, Hubn. Vermilion River. August.
E. Americalis, Guen. Mattawa. July.
Eutrapela Transversata, Drury. Montreal River and Trout River
to the north of it. August.
E. Transversata, Drury, Var. Vermilion River. September.
Therina Fervidaria, Hubn. (2) Montreal River. August 9th.
Sicya Macularia, Harris. La Cloche. July.
Angerona Crocataria, Fab. Sault Ste. Marie. July.
Corycia Vestulata, Guen. Sault Ste. Marie. July 2nd.
C. Semiclarata, Walk. Sault Ste. Marie. June 30th.
Semiothisa Granitata, Guen. Vermilion River. August.
Cleora Pulchraria, Minot. Montreal River, August 9th; (2)
Onaping Lake, September 11th.
Triphosa Dubitata, Steph. Near Onaping Lake, September
Township of Levack, October.
Rheumaptera Unangulata, Haw. Sault Ste. Marie. July.
R. Hastata, Linn. (2) Sault Ste. Marie. July.
Hydriomena Sordidata, Fab. Var. *Glaucata*, Pack. Sault Ste.
Marie. July.
Salebria Fusca, Haw. Sault Ste. Marie. July.

APPENDIX IV.

MEANINGS OF INDIAN GEOGRAPHICAL NAMES IN THE COUNTRY AROUND SUDBURY.

During the progress of our surveys and explorations, care was taken to obtain from the local Indians the meanings of their geographical names as far as they were able to give them. My own knowledge of the Ojibwé or Otchipwai language enabled me to verify these in most cases. But all the translations in the following list have been submitted to Mr. Robert Ross, of Naughton, and Professor John Galbraith, C.E., of Toronto, both of whom have a knowledge of this language. Some of these names have the Cree rather than the Ojibwé form, from which it appears probable that the Crees, who now inhabit the country around James' Bay, may have at one time extended further south. The meanings of these Indian names are often obscured by contractions, which are very common in the Ojibwé dialect, and also by corruptions that have crept in by carelessness and have been adopted by the Indians themselves. The spelling in common use is given with the addition, in some cases, of what is believed to be the correct form. In the pronunciation, it is to be understood that the value of the letters is the same as in French, which gives the sound much more correctly than by using the English pronunciation. Most of the Indian geographical names are in the locative form, so that *at* or *the place of* is to be understood in addition to the interpretation given in this list. The names are in alphabetical order.

Ashigan-ipoon-sap-agaming—The lake where nets are set for bass in winter.—A lake just south of Koo-ka-gaming Lake.

Ka-bi (or pi)-to-ti-twi-a—The stream having the same course as (or continuing the course of) another stream; or it might, in other cases, mean the stream parallel to another stream.—A branch of Sturgeon River from the west in townships 25 and 23, which has the same course as the stretch of the latter just below it.

Ka-kake-shi-wish-ta-gwa-ning—The cormorant's head.—A rock forming part of the cliffs on the west side of Onaping Lake, a short distance north of Proudfoot's line.

Ka-min-i-tik-wia-kwuk—River having many islands.—A stream in the township of Morgan.

- Ka-si-sé-gan-da-ga-wonk—Where there are spruces.—A lake west of upper Vermilion River and near Proudfoot's east-and-west line.
- Ka-wa-wi-ai-gama—The round lake.—Situated east of the outlet of Onaping Lake.
- Ka-wa-sa-ski (or hi)-gama—The lake of bays.—A lake on a small river of the same name which flows into the upper Vermilion from the west.
- Ka-wak-won-é-ka-gama—Lake where *tripe de roche* is plentiful.—Situated a short distance west of Upper Vermilion River.
- Kin-ni-wabik—(Golden) eagle's rock.—A lake in the south-eastern part of Levack, which the surveyors have called "Moose Lake."
- Kitchi-mish-kwis—Big grass.—A branch of Vermilion River from the north.
- Kino-gami—Long lake.—Between Lake Panache and Wahnapitæ Station on the Canadian Pacific Railway.
- Koo-ka-gaming—Owl lake.—A lake nine miles long, situated a short distance east of Wahnapitæ Lake.
- Ma-ko-ping—Contraction for bear lake—literally, bear's water.—The aboriginal name for the sheet of water which has been re-named "Windy Lake," on the line of the Canadian Pacific Railway north-west of Sudbury.
- Mat-ta-ga-ma-shing—A contraction for Mat-ta-wa-ga-ma-shing—The meeting of the waters—literally, the place where the lakes meet together.—At this sheet of water two arms meet and into each of them a canoe-route falls. A lake laying just east of Wahnapitæ Lake.
- Maskin-ongé-wa-gaming—Big pike lake.—Between Sturgeon River and Wahnapitæ Lake.
- Maz-in-in-waning—The pictured water.—So called from the reflection of the landscape on the calm water in the summer evenings. Situated in the township of Fairbank. The surveyors re-named it "Vermilion Lake."
- Ministik (Sa-kuh-i-kun)—Island lake (Cree).—A lake on the town-line between Ermatinger and Cascaden.
- Miska-wi-ko-bang—Place of the rushes.—A lake about ten miles north of the township of Lumsden.
- Muck-a-tai-wa-gaming—Black lake.—On the east side of the Whitefish Indian reserve.

Na-mai-gus (or goos)—Trout (the large grey or lake trout).—A lake east of Onaping River.

Ni-nips-ka-gaming (or Ni-bish-i-ka-gaming)—Leafy lake—The source of Vermilion River.—Situated a short distance east of Onaping Lake.

Nipissing—A contraction for A-nib (or nip)-i-sing—The place of elms. Or, possibly, it may mean the little lake—as compared with Lake Huron.—Lake at the head of French River.

Nita-wa-gami—Lake where the stream is born—A lake in the northern part of Snider. Re-named Whitewater Lake by the surveyors.

O-na-ping.—May be a contraction for O (or wun)-num-un-a-ning—Cree for red paint or “vermilion” place. Perhaps the reason why the river from the junction of this stream with what the Indians call the Onwatin, has received the name of Vermilion River, is to be traced to this meaning. Onaping might also be a contraction for Oo-na-min-a-ping—place of gooseberries, Oo-na-min being the word for the fruit we call gooseberries in the dialect of the Crees around James' Bay, although shabomin is the name of these berries in the Ojibwé dialect.

On-wa-tin—Calm or smooth—literally no wind.—A lake on the Vermilion River, regarded by the Indians as the source of the main river, which is known among them by the same name.

Pawa-tik, or Pow-a-tik—Rapid.—A small river which flows through township 66.

Pay-pun-aka-mas-kik—Probably a contraction for Pay-i-pa-pun-aka-mas-kik. Where the sun shines out upon the other side, or there is a glint of sunshine over on the other side of the water.—A lake between the Onaping and upper Vermilion River. Its northern extremity touches Proudfoot's east-and-west line.

Pi-mitchi-wan-ga (or ka)—Probably for Pi-midgi-i-wan-ka—Place of running water.—A lake on the upper Vermilion River.

Ping-wi-i-min-ka-ni-wi (sipi)—Sand-cherry river with the two branches.—A small river flowing into the township of Morgan.

Po (or pa)-gama-sing—A contraction for either Opa-gama-sing, Lake-of-the-narrows or Pa-gwa-gama-sing, shallow lake. Lake of the Shallow Narrows would be an appropriate name.—A lake ten miles long, situated just west of Spanish River, opposite the station of the same name on the Canadian Pacific Railway.

Sa-ga-mook—The Peninsula.—The name of an Indian village situated at a peninsula on the north shore of Lake Huron a few miles west of La Cloche.

Sagitchi-wai-a-ga-mog—Lake with the hills where the water goes out. Sagitchi is a single particle and means out of, or out from, and wai is a contraction for wai-tchu, a hill.—A lake situated just north of the township of Lumsden.

Schkow-a-na-ning (for Wa-ska-wa-naning).—The place of the turn (in the canoe-route). A lake east of Onaping River.

Shi-ba-o-na-ning—The channel.—The original and proper name of a place on the north shore of Lake Huron. Called also "Killarney."

Shing-wak—White pine.—A lake a short distance east of Onaping River.

Temagami—Deep lake (in the Ojibwé or Otchipwai dialect).—A lake thirty miles long between the Montreal and Sturgeon Rivers and sending a stream into each.

Temiscaming—Deep lake (in the Cree dialect).—On the Ottawa River, where it changes its general course from west to east.

Wab-a-gi-(or ki)-zhik—Clear or white sky.—A lake in the southern part of Nairn.

Wah-na-pit-æ—More correctly Wa-na-pit-é-(ping), the final syllable being merely locative, as it was formerly spelled upon the maps. The change to the present incorrect form was introduced by the late Mr. Alexander Murray when he surveyed the lake in 1856, and arose from a misapprehension of the proper pronunciation of the diphthong æ and which, moreover, does not occur at all in the Cree or Ojibwé language. The accent is on the final é. The h is the first syllable is unnecessary, as the a alone is sufficient, being always pronounced soft and long in the Ojibwé language. A return to the proper and simpler spelling would be welcomed by everyone who has occasion to write this name often. The word means hollow (molar) tooth and was probably suggested to the Indians, who are good map-makers, by the fact that the outline of the lake resembles that of a side view of a molar tooth. It is the largest lake on the river of the same name.

Wa-na-tanga-(sa-gai-(hi)-gan)—Hollowed-rock lake.—Situated east of Onaping River and north of the township of Levack.

Was-ka-gaming, for Oja-wask-ka-gaming—Green or blue lake, these colours having only one adjective to denote them. Called Lake Panache, (Antler Lake) on the maps.

Wa-shai-ga-mog—Clear lake.—A lake in the south-west corner of the township of Fairbank. Re-named, contrary to the wishes of the natives, “Fairbank Lake.” A similar name with the prefix ka belongs to a lake in township 66.

Was-ki-ga-mog—the lake that curves round.—A hook-shaped lake on the Maskinongé River, not far west of Sturgeon River.

We-quet-(sa-gai) (hi)-gan)—Bay lake.—In the township of Ermatinger.

Wenge-kis-i-naw—Why is it cold?—The name of an Indian, after whom a stream north-west of Morgan, and passing through his hunting ground, is called.

Wia-shai-ga-mog—Clear lake.—The same as Wa-sha-ga-mog.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

THE GEOLOGY OF

HUNTERS ISLAND

AND ADJACENT COUNTRY

BY

W. H. C. SMITH, C.E.



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY

1892.

To A. R. C. SELWYN, C.M.G., LL.D., F.R.S.,
Director and Deputy Head of the
Geological Survey of Canada.

SIR,—I herewith submit to you my report upon the physical and geological features and economic resources of Hunters Island and adjacent country, lying principally in the Rainy River district of the province of Ontario, but extending eastward five miles and a half across the eastern boundary of this district into Thunder Bay district; also a geological map of the same on a scale of four miles to the inch. The sheet, No. 7, Ontario, embraces an area of eighty-seven and a half by forty-eight miles. The usual size of the sheets of this series is seventy-two by forty-eight miles, but fifteen and a half miles are added to this sheet to the west, in order to show on the one sheet that small portion of Canadian territory lying south of the eastern part of the area embraced in the Rainy River sheet, already published, and thus avoid the publication of a second seventy-two by forty-eight mile sheet, only a very small proportion in the north-east corner of which would be Canadian territory. Only about one-third of the area depicted on this map is in Canada, the boundary line between Canada and the United States extending in a sinuous line completely across the sheet.

All the topography north of this line is from our own surveys, checked and in some cases supplemented by township surveys, mining location surveys, timber limit surveys, and the survey of the boundary line between the districts of Rainy River and Thunder Bay by the Provincial Crown Lands Department.

All the topography on the American side is compiled from the best American maps extant.

The examination of the area was originally under the direction of Dr. A. C. Lawson, who, however, resigned before the work was completed. As his assistant, my work was for the most part topographical. The geological notes, taken in conjunction with those for the topography, were only intended to be supplementary, and in many places where surveys were not required, the writer took no geological notes. With a few unimportant and isolated exceptions, the main geological boundaries were, however, laid down by Dr. Lawson on the map, prior to his departure. These boundaries he determined partly from his own observations and partly from those of the writer, but he

had not indicated on the map the subdivisions of the Keewatin series, therefore the report is brief and incomplete.

The area of Canadian territory on this sheet being small comparatively, and the publication of the map having been already much delayed, it is deemed advisable to publish it at once, rather than to wait another year in order to acquire information for the minuter subdivision of the rocks of the Keewatin series.

I have the honour to be, sir,

Your obedient servant,

W. H. C. SMITH.

OTTAWA, 3rd May, 1892.

NOTE.—All bearings have reference to the true meridian.

REPORT
ON
THE GEOLOGY OF
HUNTERS ISLAND
AND ADJACENT COUNTRY.

INTRODUCTION.

This report, with its accompanying map, is a continuation of the work commenced by Dr. A. C. Lawson in 1883, in the Lake of the Woods region. Since then his reports on the Lake of the Woods, Rainy River and Rainy Lake together with three sheets of the map have been published.

This sheet, lying to the south and east of the Rainy Lake sheet, is position of the fourth of the series published, although it is numbered "7," in accordance with a systematic numeration of the sheets of this series, which it is intended to publish.

The present report and map embody surveys and geological investigations made in the latter part of the summer of 1887, during the field investigation. Period of summer of 1888 and part of the summer of 1889, during which time I was acting as topographer and assistant to Dr. Lawson.

In the summer of 1887, I was assisted by Mr. William Lawson. Work of The early part of the summer was occupied in finishing the topography season 1887. required for the Rainy Lake sheet. We left Fort Frances on the 5th of August and commenced work on the area covered by this sheet on the 9th of August. Micrometer and compass surveys were made of all the lakes and streams north of the international boundary shown on this map west of Lac la Croix, with the exception of Little Vermilion and Loon lakes and the intervening stream; thence from the eastern boundary of Indian Reserve "D," we surveyed the Maligne River, carried a micrometer and compass line along the south side of Sturgeon Lake, and continued this line through Russell and Chatterton lakes to

Keat's Lake, which we surveyed, with the river stretches and lacustrine expansions to Kahnipiminanikok Lake, through which we carried the line ; thence up the Kahnipiminanikok River to Saganagons Lake, where the system of surveys was connected with the mining locations which approach within a few chains of the south-west arm of this lake, and which had already been connected with the American township surveys. The lakes and rivers above enumerated form the north-western, north-eastern and eastern boundaries of that area to which the name of Hunters Island has been given. The south-eastern boundary is formed by the northerly shores of Saganaga and Swamp lakes, by the Swamp Portage, by the north-western shores of Cypress, Big Knife, Carp and Birch lakes, with their connecting streams. Basswood Lake forms the southern boundary, while Crooked Lake, with the stream which pours into it the waters of Basswood Lake, and that which carries the waters of both into Lac la Croix, form the south-western boundary.

The work on the northern boundary of Hunters Island was finished on the 30th of September, and the season's work brought to a close at Silver Mountain on the 7th of October.

Work of season 1888. In the summer of 1888 Mr. Wm. Lawson again assisted me, and from the 29th of June to the 24th of August, we were continuously engaged in surveying, by means of the compass and Massey patent boat log, the lakes bordering Hunters Island to the north-east, and those in the interior of the island east of, and including, the lakes and streams forming the route from Shelley Lake through Keefer to Kashapiwigamak Lake. In addition to these, Ross, Beaver and McKenzie lakes were surveyed during this period.

From the 24th of August to the 12th of September, we were engaged on work in the area included in the sheet north of this, the Seine River sheet (No. 6 of the series.)

Between the 15th and the 19th of September we surveyed Wink and Pooh-Bah lakes, with the creek and portage connections between these and Sturgeon Lake and River. The next week was spent in the Seine River sheet, but the remainder of the season, from the 27th of August till the 18th of October, was spent in the south-western and northern Laurentian areas of Hunters Island, during which time nearly all the lakes shown in these portions were surveyed wholly or in part.

Work of season 1889. In the summer of 1889 I was again assisted by Mr. Wm. Lawson. Work was commenced at Savanne on the 6th of June, and continued until the 12th of August, on surveys in connection with the Seine River sheet. From the 14th till the 25th of August, while Mr. Lawson continued working in this sheet, I was employed in Hunters

Island, completing some unfinished surveys around Wicksteed, Brent, William, Conmee, McIntyre and Sarah lakes, and in investigating more closely some geological questions there, and on the south-east arm of Sturgeon Lake. The remainder of the season was spent on the Seine River sheet, with the exception of a week in October devoted to topographical work in the neighbourhood of Port Arthur and Fort William.

Much of the area embraced in the Hunters Island sheet had been surveyed for various purposes, with a considerable degree of accuracy, and for this reason it was deemed expedient to use, for the most part, the more rapid method of surveying with the prismatic compass, for determination of bearings, and the Massey patent boat log, for the measurement of distances. This log, carefully used, gives very satisfactory results and permits great rapidity of work, but it does not allow close continuous examination of the lake shores for rock exposures, as it is necessary to hold a straight course with the canoe from point to point.

The southern shores of the lakes and rivers along the international boundary line were accurately defined by the Minnesota township surveys, which afforded an excellent base line for our work. The whole of Hunters Island had been traversed with the transit and micrometer for timber limit purposes, and this survey fixed with much accuracy many prominent points on all sides. The boundary line survey, between the districts of Thunder Bay and Rainy River, the Indian Reserve surveys, and the mining location surveys, all contributed considerably to the topographical detail, and to the accuracy of delineation of the geography of the field. Some of the outlines of the northerly shores of the lakes and rivers along the international boundary were taken from Mr. David Thompson's survey under the Boundary Commission. This work, when corrected by the American township surveys, has been found to be sufficiently accurate between points thus fixed. Little Vermilion and Loon lakes, the eastern part of Lac la Croix, Crooked and Basswood lakes are the principal places where this survey was made use of.

That Man's and This Man's lakes were surveyed by Mr. McDougall of Port Arthur, and a map of them kindly given me by him. The position of The Other Man's Lake was fixed by Mr. McDougall with reference to those above mentioned, and the traverse of the shore line and island was made by Dr. Lawson.

With the above exceptions, all the topographical work of this sheet on the Canadian side of the boundary was performed by the writer and Mr. Wm. Lawson.

I may take this opportunity of expressing my appreciation, not only of the cheerful manner in which this gentleman has endured the hardships and undertaken all the tasks incidental to our explorations, but also to the readiness and ability with which he mastered the requirements of the work and to the rapidity, care and accuracy which invariably characterized his performance of it. He not only assisted me throughout the seasons during which I was engaged in the topography of this sheet, but has been working under my direction for the last two seasons, five summers in all, during three of which he has, for the most part, been engaged in making independent surveys.

Acknowledgments.

I may here also take the opportunity of acknowledging my indebtedness to all the members of the engineering firm of Russell, McDougall & Russell, of Port Arthur, for maps, sketches and information ; to the Messrs. McKellar, Mr. McIntyre and Mr. John McLaurin, of Fort William, for information, and for assisting me to secure suitable men ; to Mr. Geo. McLaurin, of Savanne, and to Mr. Alex. Matheson, of Rat Portage, for similar favours. To Messrs. Thos. Marks & Co. of Port Arthur, I am especially indebted for courtesies and favours extending over several years.

Bibliography.

The geological literature of this field is very cursory. Half a century ago the two main routes from Lake Superior to the north-west, were the Pigeon River route and the route by Lac des Mille Lacs. The former which now forms the boundary line between British America and the United States, from Lake Superior to the Lake of the Woods, is represented on this sheet between Saganaga and Namakan lakes ; the latter route joins this one at Lac la Croix. On these two routes only, therefore, do we find some brief references to the geology of the country in the earliest scientific records of the West. The earliest reference that I can find, is in Dr. J. J. Bigsby's delightful book of travels, entitled "The Shoe and Canoe," published in 1850.

Bigsby.

In the Quarterly Journal of Geological Science, for 1851, the same author, in a paper entitled the "Erratics of Canada," has a brief reference, on p. 218, to the lakes in the sheet.

Owen.

In the report of the Geological Survey of Wisconsin, Iowa and Minnesota, by Dr. Dale Owen, 1852, are references to the rocks of Little Vermilion, Sand Point and Namakan Lakes, on pages 317 and 318.

Hector.

In Captain Palliser's report of an exploration of part of British North America, Dr. James Hector under date 1857, gives a few geological notes, and a sketch map and section geologically coloured, of part of this region.

Devine.

On a map, by Mr. Devine, of the north-west part of Canada, published by the Crown Lands Department of Upper Canada, in 1857, the

part of the area shown on this sheet south-east of Sturgeon Lake and Maligne River is geologically coloured as belonging to the Silurian system.

Prof. H. Y. Hind in his report on the Assiniboine and Saskatchewan Hind. district, 1859, has a reference, on page 165, to the glacial groovings on the gneissoid rocks of Sturgeon Lake.

In the Quarterly Journal of Geological Science, vol. XVII., 1861, Hector. page 438, Hector refers to the rocks of Sturgeon, Saganaga and intermediate lakes.

Dr. Bell, in his report on the country between Lake Superior and Bell. Lake Winnipeg, published in the report of this department for 1872–73, and also in his report published in the succeeding volume, 1873–74, on the country between the Red River and the Saskatchewan, with notes on the geology between Lake Superior and Red River, briefly records some of the geological features of the eastern part of this region.

Prof. N. H. Winchell, in the 15th, 16th and 17th Annual Reports of Winchell. the Geological and Natural History Survey of Minnesota, makes occasional references to the geology of all the lakes on the American northern boundary.

Brief references to the geology of this region have been made in the annual summary reports of this department for the years 1887, 1888 and 1889.

N. H. and H. V. Winchell, in their joint report on the Iron Ores of N. H. and H. Minnesota, 1890, refer to the rocks of Saganaga Lake. V. Winchell.

Mr. H. V. Winchell, in the "American Journal of Science," for May, H. V. Winchell. 1891, publishes an article on the same rocks.

In the same journal, for April, 1892, Dr. A. R. C. Selwyn publishes Dr. Selwyn. an article on the "Geological Age of the Saganaga Syenites."

PHYSICAL FEATURES.

The whole of the area, comprised in this sheet, is of the "*rocky lake*" character described by Dr. Lawson* and presents, particularly in the schistose areas, the same intimate dependence of lake and river shore lines upon the direction of the strike, cleavage or lamination of the rocks.

The surface features of the country present a rough hummocky succession of low-rounded hills, with irregular depressions occupied by lakes and their connecting streams. A few well marked continuous ridges, roughly parallel to each other, occur in the eastern part of Hunters

Surface
features.

Ridges.

*Geological Survey of Canada, Annual Report, vol. III., 1887-88, Part I., p. 11 f.

Island, the most important and regular of which is that running north-west of Knife and Cypress lakes and which consists largely of green-stones, with which are associated the jaspilite and iron ores. These ridges run in a general north north-east direction. They follow closely the strike of the rocks, and continue with occasional depressions for from ten to twenty miles. These hills are particularly high and precipitous in the schistose area, rising to a height of about 300 feet above the level of the neighbouring lakes. The shores of Emerald and Big Rock lakes are especially high and rugged, the ridge between them probably marking the line of greatest elevation in the area comprised in this sheet.

Arctic and
Atlantic
divide
Branch
watershed.

Drainage of
Hunters Is-
land region.

Elevations.

Previous
estimated
elevation.

The watershed between the Arctic and Atlantic slopes passes between North Lake and South Lake, sixteen miles east of this sheet, in a west south-west direction, and a branch of this divide crosses the Swamp Portage, and thence in a sinuous line, but general westerly direction, across Hunters Island, separating the waters that flow around the north-east and north-west sides of the island from those that flow around the south-east and south-west sides to meet again in Lac la Croix; whence they flow down the Namakan River through Namakan Lake to Rainy Lake. With the exception of the narrow neck of land crossed by Swamp Portage, the area known as Hunters Island is completely surrounded by water. The whole area comprised in this sheet lies on the southern margin of the Arctic basin.

Probably the highest lakes in the region are the small lakes north of Jasper Lake and Louisa Lake, neither of which can be much below the level of North and South Lakes at the main divide.

Assuming the level of Rainy Lake, as estimated by Dr. Lawson,* to be 1,182 feet above the sea, the elevation of Cypress Lake would be somewhere in the neighbourhood of 1,400 feet. The elevation of Lac des Mille Lacs, as determined by the Canadian Pacific Railway levels, is 1,500 feet above the sea, which is probably higher than any lake in this area. All the estimates of the earlier explorers, of the elevation of the lakes at the height of land, seem to have been considerably too low, while Prof. N. H. Winchell's† estimate of the elevation of Sagana-ga Lake (1,518 feet) would seem to be a little too high, the highest land, however, in the area, can hardly be less than 1,800 feet, attained not only by the ridge north of Knife Lake, but also in all probability by that skirting the south-east shores of Louisa, Glacier and McEwen lakes.

*Geological Survey of Canada, Annual Report, vol. III., 1887-88, Part I., p. 14 f.

†Geological and Natural History Survey of Minnesota, 1872-1882.

The greatest depth found, *280 feet, was in Agnes Lake, two miles from its southern extremity. Depth of water in lake.

The following short list of soundings will convey a good general idea of the maximum depth of water usually found in these lakes, which would seem to bear about the same proportion to the height of the hills surrounding them, that the area of lake surface bears to that of the land.

SOUNDINGS OF LAKES IN THE HUNTERS ISLAND REGION.

	Feet.	List of soundings.
Namakan Lake, western part	48	
Namakan River, expansion, south-west of Captain Tom Lake	34	
Sand Point Lake, bay on east side near southern end	70	
do southern expansion	43	
\ Pooh-Bah Lake, north side	50	
do south-west bay	50	
Chatterton Lake, central part	27	
McDougall Lake, northern part	30	
Keefer Lake, centre	72	
Lake north of Keefer Lake	70	
do do north-western part	50	
Kashapiwigamak Lake, two miles from southern extremity	130	
Hulbert Lake, one mile from southern extremity	33	
Lake south of Hulbert Lake, western part	25	
Williams Lake, northern arm	33	
do middle of south-west part	75	
Kahnipiminanikok Lake, two miles from northern end	80	
do three do	62	
do four and one-half miles from northern end	108	
Murdoch Lake, southern part	14	
Western outlet of Agnes Lake	13	
Agnes Lake, eastern arm	94	
do four miles from southern end	35	
do three do	102	
do two do	*280	
Robin Lake, southern part	18	

The whole country is, as a rule, very thickly clothed with forest. Forests. Most of the trees are, however, evergreens, and no hardwood trees, with the exception of a very few elms (*Ulmus Americana*), soft maple (*Acer rubrum*) and, very rarely, small ironwoods (*Ostrya Virginica*) were anywhere seen. In parts of the country that have not been more or less recently swept by fire, the principal trees are white pine (*Pinus strobus*), red or Norway pine (*Pinus resinosa*), jack pine, called by some pitch pine (*Pinus Banksiana*), and spruce, probably of the two varieties, white and black (*Picea alba* and *P. nigra*); these are, as a rule, somewhat small in size. Canoe birch (*Betula papyrifera*) is also a very common tree, but, usually, it does not in this part of the

Variety of trees found.

country grow to a sufficient size to furnish good bark for canoes. Very rarely the silver or yellow birch (*Betula lutea*) is seen of small size. The aspen poplar (*Populus tremuloides*) is very abundant, growing to large size in unburnt forests, and forming the sturdiest and quickest second-growth in portions that have been swept by fire. White cedar (*Thuya occidentalis*) is sometimes seen where the soil is deeper than usual, generally in somewhat marshy places and lining the banks of streams ; it rarely attains to any very large size and, although widely, is sparsely, distributed. Tamarack (*Larix Americana*), sometimes of considerable size, is generally found in the more extensive marshes. The balsam or fir (*Abies balsamea*) is a very common tree, but is usually smaller and less abundant than the spruce. Basswood Lake is supposed to have been named after the tree of that name, but I have seen no basswood in this part of the country, and Dr. Bell* reports that there is none, and that the name was probably taken from the whitewood or balm of Gilead (*Populus balsamifera*) which is abundant on the shores of the lake. Basswood is erroneously called whitewood by some. The Indian name of the lake is Bassmenani Sakahagun, and the first French name for it is Lac des Bois Blanes. From this it may be conjectured how the present name has been evolved.

Basswood.

Comparatively a great part of the country embraced in the area mapped has been ravaged by fire within the last half century. These devastating fires, which do so much to mar the beauty of the scenery and destroy the timber, are too often caused by the carelessness of explorers, prospectors and hunters ; the Indians are very careful to extinguish their fires during the dry season ; but it is to be regretted that the fatal carelessness of others cannot be checked ; the amount of valuable timber thus destroyed is mutely but strongly attested by the gigantic half-burned dead pines which, towering in the air, add so much to the wildness and desolation of the scene. Where sufficient time has elapsed a dense second-growth has sprung up, consisting, in places, almost entirely of jack pine, thickly clustered, sometimes of more thinly scattered, birches and poplars, but generally of all three with the addition of spruce. Frequent clumps of Norway pine often break the monotony of the burnt country. These trees remain unscathed, and where they are thickly clustered have often arrested the progress of the fires in that direction.

Forest fires.

From the character of the woods noted on the lake shores, a general idea of the extent of these fires can be gathered.

*Geol. Sur. of Can., Rep. of Progress, 1872-73, pp. 87-111.

Below is a list of the lake shores which, in 1888, were observed to have been at different periods swept by forest fires which have destroyed the best timber :—

- Namakan Lake, isolated small areas.
 Lac la Croix, west shore of western part.
 Tanner's Lake, all the north shore.
 Sturgeon Lake, nearly all the north shore.
 McDougall Lake, eastern half.
 Chatterton Lake, eastern part.
 Keat's Lake, all the shores.
 Shelley Lake do
 Kahnipiminanikok Lake, western side of northern part at intervals for seven miles along the channel to Williams Lake.
 Long narrow lake, north of Agnes Lake, western outlet.
 Agnes Lake, northern part.
 do western shore for nine miles to within one mile of southern extremity.
 do north-west shore of bay to north-east, and on eastern shore of main lake for one mile and a half north of the mouth of this bay.
 Sunday Lake, northern shore.
 Burk Lake, all except one mile of southern shore.
 Basswood Lake, north-eastern half of north-eastern part.
 Shade Lake and lake north-west of it, and small lake south of it, all shores.
 Noon Lake.
 Lake Silence, southern three-quarters.
 McNiece Lake, eastern shore.
 Kashapiwigamak Lake, both shores for four miles from southern extremities.
 Wicksteed Lake, western shore.
 Lake south of above, all the shores.
 William Lake, eastern part.
 Conmee Lake, west shore and south-eastern bay.
 Pooh-Bah Lake, all except north-western arm and north shore.
 Brent Lake, north shore of eastern part and both shores for one and a half miles from eastern extremity.
 McIntyre Lake, all except northern bay.
 Sarah Lake, all shores.
 Small lake south of Sarah Lake.
 McKenzie Lake, southern part, and northern shore of arm of Kahnipiminanikok Lake for two miles west of it.
 Kahnipiminanikok Lake, south-east shore of arm, for two and one-half miles from mouth of Kahwawiagamak River.
 Bird Lake, and southern part of bay of Kahnipiminanikok Lake east of it.
 Robin Lake, and small lake tributary to Agnes Lake south of it.
 McEwen Lake, eastern side, and portions of western side.
 Wet Lake, all shores.
 Glacier Lake do
 Louisa Lake, all shores except at southern extremity.
 Cross Lake, all shores.

List of localities where traces of fires were observed in 1888.

Saganagons Lake, Deadman Point and shore south of it to eastern extremity of lake, and north shore for three miles west of this extremity.
Ross Lake, all shores.
Beaver Lake, all shores.

Probable extent of these fires.

Without exploration, the distance to which these fires have penetrated into the interior from the lake shores, is a matter of conjecture; in many cases it is known not to be far, and probably owing to the increasing dampness of the woods in the more sheltered interiors, as the lake shores are receded from, the fires could not spread to any great distance except by repeated burnings in successive seasons; on the other hand, from the close contiguity of some of the lake shores which betray the evidence of forest fires, and from the contemporaneity of these fires on different lakes, as indicated by the second-growth timber, it is to be feared that in many cases the fires have swept over the whole intervening country from lake to lake.

A proportional estimate of the country which has thus suffered is somewhat difficult to arrive at, but in the field I concluded that not less than one-sixth of the whole area of this region had been ravaged by fire.

Periods of fires.

The second-growth timber would seem to indicate three main periods of conflagration. The first period would seem to have been about the year 1870, and the second about the year 1879 or 1880. Professor Macoun states that no extensive fires had occurred in the vicinity of Port Arthur and along the line of the Dawson route prior to 1869, and that, in 1870, fires were very general and destructive owing to the carelessness of the troops who passed over the Dawson route in that year. It is certain, however, that fires were prevalent along the line of the Pigeon River route (international boundary) long before this date, as Dr. Bigsby, in his "Shoe and Canoe," quoted above, refers to the bare hills of Saganaga Lake, and in one of his scenic sketches of Lac la Croix, the country is represented very much as it is now in that respect.

The last period of fires seems to have been quite recent, and to have affected for the most part those districts already burnt.

Pine.

There is much good pine timber in the unburnt areas, but the largest trees do not grow on the lake shores. The distribution of white pine is very general, although it bears but a small proportion to the forest timber. The finest pines were seen on Trout and Darkey lakes, the western part of Brent Lake, the south-east part of Sturgeon Lake, at several places on Kahnipiminanikok Lake, and in the northern part of Silence Lake. Isolated groves of medium-sized white pine are seen on the western side of McEwen Lake and on the north-

western shore of Russell Lake. Some fine trees were seen on Williams and Hulbert lakes, and around the south part of Brent Lake.

Regarding the character of the canoe routes traversing the district, a Canoe route. few words may be said for the guidance of future travellers. All the portages known are indicated on the map, the length being usually given in chains. The word "portage" is printed, where space is available on the map, on that side of the watercourse on which the path is to be found.

Those routes, which on the map are seen to be the shortest and to have the fewest portages, are not always the best, and are sometimes impracticable, from the number of rapids and shallows.

Of the two main routes from Lake Superior to the North-west, above Dawson referred to, *via* Rainy Lake, the one by Lac des Mille Lacs and the route to the North-west. Dawson route through Sturgeon Lake to Lac la Croix, is, in the opinion of the writer, decidedly the easiest to travel, though much the less interesting to the geologist or explorer.

The Pigeon River, or Grand Portage, or International boundary Pigeon River route, traverses the whole of this sheet. Between Saganaga Lake and Lac la Croix, the watercourse around the northern side of Hunters Island affords an alternative route. The distance between these two lakes by either route is about the same. There are fewer portages on the southern or boundary route, and there are no lengthy rapid streams which are dangerous to descend and difficult to ascend. By this route also the portages are better cut out and more easily found, but the lakes are larger and more intricate, and it is difficult for a stranger to detect at once the shortest way through them.

The old Dawson route led by one portage, four miles long, from Lac Nequaquin la Croix to Sand Point Lake; this portage is now overgrown with thick Portage. bushes and is impassable, and the traveller has the alternative of going round by the boundary line (the original route) which is undoubtedly the best, or of taking the Namakan River from Lac la Croix to Namakan Lake. This river is very rapid and turbulent: it is unsafe for the traveller without a guide who is thoroughly conversant with its many treacherous rapids and falls, and it is extremely laborious to force a canoe against its strong current. With small canoes and when the water is high a much better passage is afforded by the watercourse shown south of this river and north of David and Thompson lakes.

A route exists between Lac des Mille Lacs and Kahnipiminanikok Kawawaigamak Lake, by Kashabowie and Shebandowan lakes, and Kawawiagamak Lake and River. I am told there are twelve portages on this route, River route.

Means of access to Keewatin belt of rocks.

some of which are about a mile long, but that otherwise the route is a good one.

From Port Arthur the readiest access is obtained to the Keewatin belt of rocks in the south-eastern part of Hunters Island, by the railway to Whitefish Lake, thence by Whitefish and Arrow Lakes to the Pigeon River or boundary line route. From Cypress Lake, the upper series of these rocks is reached by Jasper Lake to Saganagons Lake, northward, and by Big Rock and Emerald lakes to Carp Lake southwestward. The portages are short and well cut out, having been prepared for the passage of testing machinery to the iron ore locations on Jasper Lake.

Routes between Sturgeon and Basswood Lakes.
Agnes Lake route.

The best route between Sturgeon and Basswood lakes is that by Russell, Chatterton, Kahnipiminanikok, Agnes and Sunday lakes. An alternative, doubtfully preferable, is offered between Agnes and Basswood lakes, by Silence, Sultry, Noon and Shade lakes. This was the old route of the Hudson Bay Company.

From Sunday Lake to Basswood Lake the traveller may pass directly by the North Portage, or by Burk Lake and three short portages, as best serves the object of his journey. Agnes Lake has two outlets into Kahnipiminanikok Lake, of which the eastern one, by Bird and Robin lakes, affords much the best route.

Kashapiwigamak Lake route.

A shorter route between Sturgeon and Basswood lakes, is afforded by Keefer, Kashapiwigamak and Yum Yum lakes, but the portages between Kashapiwigamak and Basswood lakes more than counterbalance this advantage. The alternative route between Shelly and Kashapiwigamak lakes, by Kahnipiminanikok, Williams and Hulbert lakes is in no respect to be preferred.

Darkey Lake route.

The best of the more direct routes between the western part of Sturgeon Lake and Basswood Lake, is afforded by Tanner's, Darkey, Trout and Crooked lakes. Three of the portages are rather long, but the footing on them is good, and with lightly laden canoes time could probably be saved by going this way rather than by making the long detour by Lac la Croix ; in any case it requires less time and labour to traverse the western than the eastern side of Hunters Island.

Winter route.

The most direct route through Hunters Island crosses from the southwest end of Sturgeon Lake, at the Maligne dam, across Pooh Bah, Conmee, Brent, McIntyre and Sarah lakes to Basswood Lake. On account of its directness, and the absence of steep hills on the portages, this is a favourite route with the Indians and the traders in the winter with dogs and toboggans, but it is never travelled during the summer ; of the twenty-two miles, from the Maligne Dam to Basswood Lake, nearly six are taken up by portages.

From Sarah Lake to Basswood Lake there is a route by a chain of Lakes not surveyed. lakes, indicated in dotted outlines on the map; of the five lakes on the route, two are reported by my Indian guide to be comparatively large, and of the seven portages, the one into Basswood Lake is said to be a long one. Between Brent and Sarah lakes there is a chain of lakes, indicated in dotted outlines on the map, which affords an alternative route over four portages, only two of which are said to be of any great length.

These constitute all the canoe routes in this area, which the explorer is likely to have occasion to travel.

ARCHÆAN ROCKS.

The rocks to which this report refers are divisible into the same groups as those established and described by Dr. Lawson* in the Lake of the Woods and the Rainy Lake districts. They are: A, Laurentian; B, Huronian; b-1, Coutchiching; b-2, Keewatin. The upper series consists of micaceous and hornblendic schistose rocks, for the most part fine-grained. The field evidence fails to determine satisfactorily whether any of these rocks are of sedimentary origin, but they exhibit abundant evidence of having been subjected to great thermo-mechanical metamorphism.

This series is divisible into two minor series, named by Dr. Lawson Coutchiching and Keewatin, the former of which is essentially micaceous and felspathic in its character, and possibly derived from original bedded gneisses. The upper division is more varied in character and includes hornblende schists, micaceous hornblende schists, hydromica schists, quartz porphyries, grauwackes, felsitic schists, conglomerates and agglomerates, with which are associated more or less altered volcanic rocks, and volcanic ashes. Of these minuter subdivisions, I am unable in all cases to delineate the distribution from my notes, as this work was to be done by Dr. Lawson; and no uniformity of sequence appears to be discoverable in them, so that they are all included in the one colour, the localities where I am familiar with them being indicated by letters in red, referring to notes on the margin of the map.

The lower division of rocks, of the granitic and syenitic type of Laurentian mineral composition, is in this field, for the most part, granitoid in character, and present many phenomena suggestive of the igneous eruptive origin of their present attitude with regard to the schistose series.

* Geol. Survey of Canada, Annual Rep. vol. I., 1885, 29 C. C., and vol. III., 1887-88, p. 21 F.

Subdivision
of Laurentian
rocks.

It might be possible to map the distribution of the different lithological phases of the Laurentian, but my notes are unfortunately too incomplete to do this satisfactorily. From minuter observations made elsewhere since this work was performed, I think that this subdivision is more important than it has hitherto been considered, and that we may have in the hornblendic and in the micaceous phases of these granites, rocks of different ages, the relative age of which is determinable, and the discovery of which may throw much light, not only on the genesis of the Laurentian, but on its relations to the overlying Couthiching and Keewatin groups.

A. LAURENTIAN.

Designation of
areas.

For convenience of description and for future reference, a name will be given to each geographically separated important area of Laurentian rocks. While a broad general similarity of character and of mode of occurrence obtains between the rocks of these distinct areas, each possesses individual characteristics which demand attention, and they are all separated by intervening belts of upper Archæan Huronian rocks.

Kawagan-
sikok area.

I. The granitic rocks on Sturgeon Lake and the lakes to the east as far as Shelley Lake, belong to a very large Laurentian area, the western part of which is closely defined. Its general outline forms an elongated oval, with a rounded excrescence on the south side. It is known to be over twenty-two miles wide, north of the western part of Sturgeon Lake, to the east of which the extension south of Russell Lake adds eleven miles. The longest axis has a general direction of 10° N. of E. and S. of W., and cannot be much less than one hundred miles in length. The largest portion of the area, that north of the limit of this sheet, is characterized by the great abundance and persistence of bands of mica schist.

This area will be referred to as the "Kawagansikok Area" from the largest and best known lake in its central portion.

Pooh-Bah
area.

II. The rocks surrounding Pooh-Bah Lake are lithologically distinct from those of all the other areas, and from this fact and from a certain doubt entertained as to their relative age, they require a separate designation, and the area will be referred to as the "Pooh-Bah Area."

Hunters
Island area.

III. The broad belt of granitic rocks which extends all across the area embraced in this sheet, also for more than sixty miles to the west of its western boundary, and for about forty-five miles E. N. E. of its north-east corner, will be referred to as "Hunters Island Area." The rocks of this area are, in lithological character, typical generally of all the Laurentian rocks of north-western Ontario and northern

Minnesota, so far as these are known; but the shape of the area in its irregularity of outline and great length (over two hundred miles) compared with its breadth (nowhere over twenty-five miles and rapidly tapering from the centre each way to extend in long narrow tongues) presents a marked contrast to the usual oval or egg-shaped areas of the granite gneisses in this country.

IV. A portion of a granitic area is exposed around Saganaga Lake ^{area.} which, so far as its outlines have been determined, would seem to be of comparatively regular ovoid form; about sixteen miles in extreme width; and about sixty miles long, in a direction N. 60° E. of which forty-five miles will be mapped on the sheet east of this. This area will be called the "Saganaga Area," from the name of the best known and most important lake within it.

The rocks of this area present some lithological peculiarities, and differences of opinion prevail as to their age, which will be briefly alluded to in a later part of this report. ^{Lithological peculiarities of each area.}

I. KAWAGANSIKOK AREA.

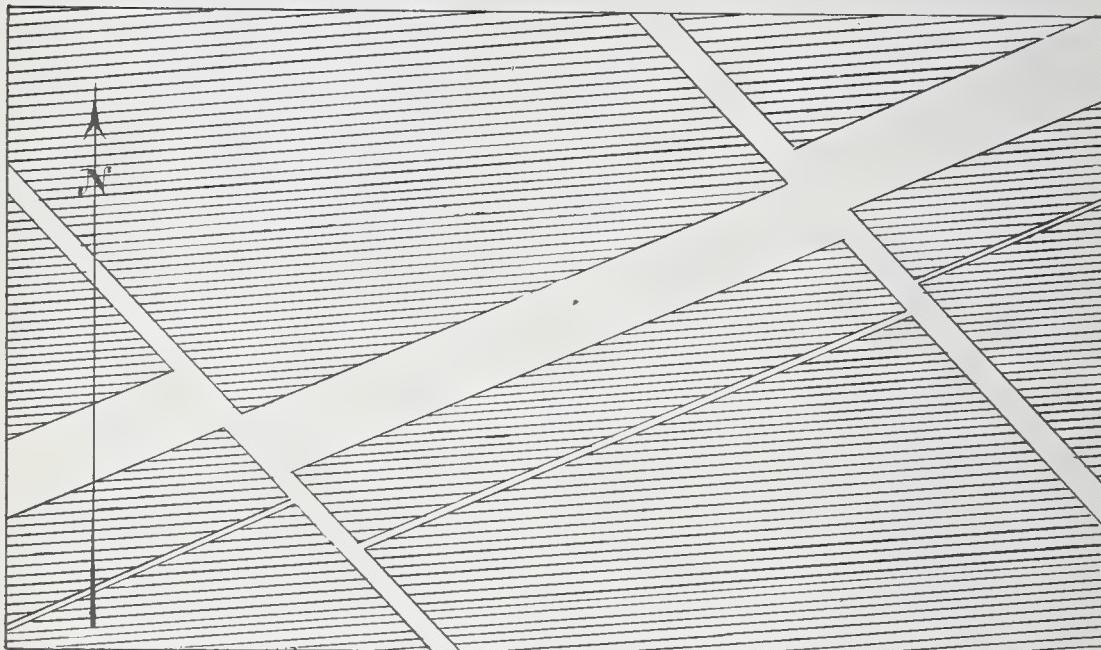
The limits of this area have been already defined as far as they encroach upon the district under consideration. This portion of the area ^{Limits of area.} so far from presenting the feature of containing bands of mica schist, so characteristic of the area to the north, appears to be unusually free from them, even in close proximity to the occurrence of these rocks to the south. A few localities in which these bands occur have, however, been already noted.

The rocks north of Sturgeon Lake are of typical pink-gray granite ^{Sturgeon Lake portion.} gneiss, usually distinctly foliated on the islands and on the more southerly points of the north-west shore, but appearing less distinctly so, as the distance from the line of contact increases. A hard, red, fine-grained granite, almost devoid of mica, hornblende or any of their decomposition products, occurs on the north side of the narrows at the east end of the western portion of Sturgeon Lake. Here a feature, very common, particularly in these felsitic granites of the Laurentian, is seen, viz., a parallel system of jointing planes a few inches apart. The constituent minerals of the rock do not show any parallelism of planes. arrangement.

On the north-west shore of Sturgeon Lake, the rocks are also characterized by the presence of small irregular areas of very coarsely crystalline rock, or pegmatite; sometimes these areas are irregularly circular in form and sometimes gradually merge, by diminution in the size of the crystals, into the ordinary medium-grained granite, but as a rule there is a more or less sharp line of demarcation. Very frequently

the pegmatite occurs in distinct and uniform veins. A most excellent example of such veins is figured below, from an occurrence on the point between the two bays close together, and running north from the centre of this part of the lake.

Fig 1



The unshaded portions represent the veins of coarsely crystalline quartz, orthoclase and bleached mica. The figure is correctly drawn to a scale of eight feet to an inch, and the veins are as regular and straight as represented. As a rule however the veins are not so straight and uniform. The shading lines represent the direction of the foliation planes of the inclosing gneiss. From the "faulted" occurrence of the veins, it would seem that they have been filled in, probably by infiltration from the inclosing rocks, after the gneisses had been cracked and faulted, as the age of the veins running in both directions is evidently the same. The rocks of that portion of this area, in which are Russell, Chatterton, and the smaller lakes to the south, are characterized for the most part by the presence of muscovite, sometimes associated with, sometimes replacing, the biotite constituent of the granites. The presence of muscovite does not appear to have any especial significance, but it is observed that the presence of garnets in the granite gneiss, which in this part of the area is a notable feature, appears to be, in a measure, a function of the presence of muscovite.

Garnets

Muscovite.

Muscovite granites are particularly noted on the western part of Russell Lake and a little muscovite occurs in all the red granites around the shores of the south-eastern extension of Sturgeon Lake and of the lakes to the east tributary to this, and on the west side of Chatterton Lake where the granites are a dull whitish colour. Muscovite is the only micaceous mineral in the rocks of the south-east bay of McDougall Lake. Muscovite as well as biotite occurs in the rocks of the east side of Chatterton Lake.

Garnetiferous granite gneisses are characteristic of the shores of the eastern or rather central expansion of Sturgeon Lake (a large expansion north of the northernmost point of Hunters Island is locally called this), particularly on the southern shores, and on the south side of the channel to the north-eastern part of the lake above referred to.

Pegmatitic granite is of such frequent occurrence around this portion of the lake as to form a large proportion of the rock exposures. It occurs principally in irregular patches, often 100 feet or more across; sometimes a gradual differentiation of the pegmatite into the medium-grained granite is observed, but as a rule a more or less distinct line of demarcation is noticeable.

South-east of this, in the extreme south-eastern expansion of the lake, some straight uniform veins of pegmatite, only two or three inches wide were observed, cutting the red granite, which is here devoid of structure and contains a very little muscovite mica. The veins have weathered more than the inclosing granites, and form shallow channels or troughs in the surface of the rock.

It has been observed that, speaking generally, this aggregation of coarse crystals in veins and irregular areas, usually consists of orthoclase quartz and mica in the granitic rocks, and as a rule, almost wholly of white orthoclase with a small proportion of quartz, but with little or no mica in the Coutchiching and Keewatin rocks; and that in these latter the orthoclase crystals do not attain to so large a size. A much more frequent exception to this rule is found in the felspar rock, as distinct from pegmatite, associated with the granites, than in pegmatite associated with the newer rocks.

At the north-east end of the main body of Sturgeon Lake, a bedded structure is apparent in the rocks. This, however, is probably a series of jointing planes simulating this structure.

II. THE POOH-BAH AREA.

Limits of Area, Character of Contact and Lithological Characters.

The rocks of this area may be generally described as very coarsely crystalline aggregations of hornblende and felspar, generally ortho- Description of rocks.

clase. The felspar crystals are often twined, but they seldom exhibit the fine striation due to multiple twining, characteristic of plagioclase. While individual felspars attain to sizes larger than neighbouring crystals, the rock is not a true porphyry. On an island one-third of a mile south of the prominent point on the west side, felspar crystals were measured three inches in length; here the rock is intersected by jointing planes, but with no uniformity of direction. In places, particularly on the west side of the lake, a rough parallelism of arrangement among the constituent minerals is barely discernible on the surface, and sometimes the rock shows an inclination to cleave in parallel directions under the hammer, but it cannot be described as being foliated.

Hornblende granite.

In some localities the hornblende syenite merges into a finer-grained hornblende granite, by the addition of a little quartz, and on the western part of the large island, in the northern part of Pooh-Bah Lake, the rock becomes quite fine-grained. In some localities, associated with the hornblende syenite, is a finer-grained, decomposed, greenish-black felspathic hornblende rock, containing sometimes a pyroxenic constituent, and generally many disseminated scales of black mica.

These are probably local phases, where the felspar has become subordinate and the hornblende partly changed to chlorite, with the biotite developed as an accessory mineral.

Localities where this rock occurs.

Occurrences of this rock were observed at the south-west end of Pooh-Bah Lake, near the portage; on the north-west shore, one mile north-east of the portage; and at several points along the south-east shore, to the eastern end; but none were observed in the more central portions of the area.

At the point on the south shore, near the east end of the lake, associated with this decomposed rock, is a hard black coarsely crystalline hornblende felspar rock, the felspar apparently one of the triclinic varieties (diorite).

Limits of Pooh-Bah area.
Wink Lake.

The Couthiching rocks of Wink Lake are represented by fine-grained light gray evenly laminated biotite gneisses; on the south shore merging into felspathic mica schists, elsewhere, particularly on the northern end of the lake, sometimes containing siliceous nodules. The syenites are represented on this lake apparently only by a red medium-grained hornblende granite, containing some large crystals of felspar perhaps porphyritically developed. This rock is lithologically the same as the dark gray medium-grained rock found associated with the hornblende syenites of Pooh-Bah Lake, on an island near the south shore one mile and a quarter east by north of the portage from Wink Lake.

Hornblende granite is seen in various exposures for three-quarters of a mile on the north-east side of Wink Lake, where indicated, and on the adjacent islands. Its contact with the mica schist is concealed under the waters of the lake or under the boulders and marshy land of the shore.

The outlet of Pooh-Bah Lake is eroded entirely out of the mica schists and on the west shore of this lake south of the outlet, the contact line can be very closely located by the proximity of adjacent exposures of each variety, although the actual junction is concealed. The whole of the north shore of Pooh-Bah Lake is occupied by mica schist, becoming in places, particularly near the syenites, very hard, compact and fine in texture, and hornblendic in composition.

On an island near the north shore, forty-five chains east of the portage to Hoffmann Lake, is an almost aphanitic, hard grayish-black rock, containing very much iron pyrites, very slightly schistose and resembling a fine diabase; it is, however, close to the line of junction and strictly parallel with it. A continuation of the band is seen on an island to the north-east and on the main shore, where it is more schistose and less fine-grained. In this band, where schistosity is visible on the last island mentioned, the planes of schistosity are much contorted, and the rock is cut by bands of granite and felspar rock.

The contact line can be traced with considerable accuracy through the islands and between them and the main shore, and although it cannot be seen exactly in the north-east bay, it can be located within the limits of accuracy definable on the scale of the map.

The whole of the eastern and southern shores of the lake, as far as can be judged from the comparatively few exposures they afford, is occupied by the hornblende syenites, with their local varieties.

A single exposure of mica schist on the extreme south-west shore, with several exposures of very coarse-grained hornblende syenite a few chains east of it on the north shore, define the contact with the mica schists, which are exposed at intervals across the portage to Wink Lake.

It is here observed that the mica schists become less massive and compact as the distance from the syenites increases.

The contact can be again located with considerable accuracy on the first lake south of Pooh-Bah Lake, on the winter route to Conmee Lake, and the contact line from here to the last determined point is probably closely approximate as laid down.

East of this the line of junction is conjectural, and is inferred to be approximately located as indicated on the map, from the convergence

North side
Pooh-Bah
Lake.

Contact in
south-west
end of lake.

Metamorph-
ism of schists
near contact.

Contact south
of Pooh-Bah
Lake.

Limits of area
east of Pooh
Bah Lake.

of the strike of the mica schists in their most easterly exposures, to the north and to the south of Pooh-Bah Lake. It has been found that the line of contact is conformable with the strike of the rocks, and from the rapid convergence of these strikes it would seem evident that the syenites do not extend very far east. The ovoid termination given to the area is representative of the usual form assumed by these small areas, wherever they have been worked out accurately. The country between Pooh-Bah Lake and the eastern part of Sturgeon Lake is very rugged and affords no means of access by canoes, and very few exposures of rock certainly *in situ* are revealed.

Possible continuation of granites south-east of Sturgeon Lake.

It is possible that this area connects geographically with, and is a western extension of, the granite area south-east of Sturgeon Lake; but this is very unlikely, in consideration of the probable and revealed directions of structural planes already detailed, and from the great dissimilarity, in general characters, between the rocks of the two areas and from a well-founded doubt as to their being of one age.

General character of contact.

From the foregoing, it will be seen that the syenites and mica schists were nowhere observed in actual contact, but from the close proximity of adjacent exposures of the two classes of rock, from the absence of bands of mica schist in the syenites and of the syenites in the mica schists, the brecciated aspect of the contact so characteristic of the granites elsewhere, seems to be here entirely wanting.

Outcrops of felspathic hornblende rock.

Several outcrops of the greenish-black micaceous hornblende rock described as associated with the syenites are found in very small areas among the mica schists, particularly at the south-east end of Wink Lake.

Reasons for correlation of rocks of William Lake with those of Pooh-Bah Lake.

The small area of rocks mapped in the same colour as the Pooh-Bah area, extending from William Lake to form the tongue of land in the western part of Brent Lake, are assumed to be of the same origin and age as the Pooh-Bah syenites, from the strong similarity between them and the associated greenish-black felspathic hornblende rocks of the latter.

Character of hornblende rocks of William and Brent Lakes.

They may generally be described as coarsely crystalline, hornblende rocks, frequently containing a felspathic constituent and occasionally having some scales of black mica, probably secondary, associated with them. The felspar cannot be determined macroscopically, but appears to be orthoclase. The structure in the field has been very closely worked out, and the map exhibits their relations to the mica schists and granites with all the accuracy possible to the scale. These rocks are observed to be nowhere in direct contact with the granites, but to be surrounded on all sides by mica schist strictly conformable in its strike to the outline of the hornblende rocks. The band of mica schists intervening between them and the granites to the east is only a few chains wide.

Surrounded by mica schist.

The aspect of the hornblende rock in its relations to the mica schist, is that of an eruptive boss. On the south-east side of William Lake, about thirty chains north-east of the portage into Brent Lake, and in the west bay of the latter, the mica schist is seen to be very much contorted and crumpled. In William Lake, associated with the crumpled mica schist, are bands of granitic rock very similar to the bands found usually in the contact zone between the Laurentian and the Cutchiching rocks, and these bands, quite conformable with the schist with which they are intercalated, have suffered the same contortions. They may be later segregations, but it is difficult in the field to avoid the conclusion that the structure is due to a later intrusion of the hornblende rocks through the contact zone between the Laurentian and Cutchiching rocks. In that case, as the date of folding of the Cutchiching and Keewatin rocks was in all probability the same, these hornblende rocks would be Keewatin or post-Keewatin in age.

This may or may not involve the age of the Pooh-Bah syenites, as the correlation of the two is a doubtful one; but as the question involves broad and general issues, it will be discussed later under "Theoretical Considerations."

III. "THE HUNTERS ISLAND AREA."

As before stated, the rocks of this area are typical of the Laurentian series in this part of the country, and a general description of them applies also to the Kawagansikok area partially exposed in the area of this sheet.

The rocks vary in colour from white through shades of gray and pink to dark gray and deep red. In texture, they vary from almost aphanitic, in the unmicaceous varieties, to such extreme coarseness of crystallization, as to characterize them as pegmatites, nor can any general law be as yet formulated which the rocks seem to follow in this particular.

Sometimes large crystals of orthoclase developed porphyritically in a finer-grained ground-mass, are observed, but no deduction with regard to any stratigraphical significance of these occurrences could be drawn from such observations as were made in this connection.

The foliation of the granites has been observed with some care, and while it may be stated as a general rule, that in the neighbourhood of upper Archæan areas the granites are more or less distinctly foliated, and that in the central portion of granitic areas the rocks show very faint traces, if any, of this foliation, still, the rule is by no means without exceptions to both statements. The localities where the rock exhibits very few or no traces of parallelism in the arrangement of its constituents, are indicated on the map by short red lines drawn

in all directions, and can be considered as reliable only on the shores of the lakes ; those localities where the rocks are more or less distinctly laminated are indicated by a parallelism and continuity in the direction of these red lines ; again these give reliable information only on the lake shores, where they have been observed, and where corroborated by the strikes shown ; however, it is probable that the structure thus indicated is the true one.

Composition. In composition, the rocks are usually biotite granites in which the orthoclase and quartz are very constantly present ; but the biotite is often replaced by, or associated with, muscovite or hornblende, and in many places these bi-silicates are changed to chlorite. It is probable that a minute proportion of plagioclase is a more or less common constituent, but in the Kawagansikok and Hunters Island areas it can seldom be detected by the unaided eye.

Limits of area. The limits of the Hunters Island area, in so far as it occurs in Canadian territory on this sheet, have been already described in defining the limits of the Huronian, or upper Archæan, rocks.

Namakan Lake. The Laurentian rocks of Namakan Lake are massive reddish granite, for the most part not foliated, although in places faint structural lines are visible. This granite holds in places bands of mica schist, which would appear to be large included fragments broken off from the main series.

Sand Point Lake felsites. On the east side of Sand Point Lake at, and on the prominent point north of, the narrows in the southern part, the granite changes into a very fine-grained hard red rock, containing very little if any bi-silicate, and is more truly a felsite than a granite. No foliation of the constituent minerals is observable, but it is intersected by well marked sharp cleavage or jointing planes in three directions : One horizontal, the other two vertical and nearly at right angles to each other ; these planes cut the rock into small rhomboidal blocks, often less than a foot in largest measurement, although in places the blocks are very large. This is a very common feature, particularly in the felsitic granites. The change from this phase of the granite to the more micaceous and coarser variety, appears to be somewhat gradual, and there is little doubt that the felsites are merely local phases.

Localities of felsites. This felsitic phase of the granite is not at all uncommon, and is seen in many places, among others :—

Kahnipiminanikok Lake. On Kahnipiminanikok Lake, on the west side of the two large islands extending from the second to the fifth mile from the northern end, and on the main shore opposite.

On the lake south of Hulbert Lake.

On the south part of Agnes Lake. Here a gradual transition from Agnes Lake, the felsites (by the introduction first of chlorite, then of biotite, accompanied by a gradually increasing coarseness of texture) into the ordinary biotite granites, is seen, not only in the direction of the structural planes, which are almost indiscernible in the felsites, but also across this direction.

Felsites are seen north-west of Louisa Lake, where in places they are quite aphanitic and become a felstone.

About the narrows between Sand Point and Vermilion Lakes the ^{Sand Point} _{Lake.} granites have a porphyritic structure. The rock is massive and granitoid.

On the boundary route from Lac la Croix to Basswood Lake many ^{Lac la Croix} _{to Basswood} _{Lake.} varieties of typical Laurentian granite and granite gneiss are seen; but the rocks are generally faintly foliated, pink, biotite granite gneisses.

Dr. Bell* describes the rocks of Basswood Lake, east of the Hudson's Bay Company's post, as "rather fine-grained, bright, light gray and reddish-gray syenite, consisting of crystalline white or red felspar and black hornblende, with more or less quartz in some parts."

In Wicksteed Lake the rock is very coarse-grained, in many localities ^{Wicksteed} _{Lake.} pegmatized, particularly on the south shore; is usually light pink and not foliated, and is characteristically a muscovite granite. On the northern shores it becomes a medium-grained muscovite biotite granite gneiss, somewhat distinctly foliated.

On the lake south of this, and west of Darkey Lake, the muscovite granite is deeper in colour, finer in texture and contains a little biotite.

It has been thought advisable to indicate on the map the localities ^{Muscovite} _{localities.} where muscovite occurs as a more or less prominent constituent of the granites, and this has been done by placing the letter (*a*) in red in such places. Similarly the occurrence of garnets is indicated by the letter (*b*) in red on the face of the map.

The eastern shore of the southern part of Darkey Lake is occupied ^{Darkey Lake.} by coarse-grained reddish biotite gneiss, associated with some subordinate bands of mica schist. On the west shore almost continuously, is exposed a dark reddish-gray micaceous gneiss, quite distinctly foliated in bands, with more massive phases intervening.

The rocks of Conmee Lake, and the western part of Brent Lake, have Brent Lake. been already described. In the north-westerly bend of the latter, between the eastern and western parts, the granites on the west side

*Rep. of Progress Geol. Survey of Canada, 1872-73. Report on the country between Lake Superior and Lake Winnipeg, p. 94.

present high precipitous cliffs, due to vertical jointing planes. In the eastern part the rocks are pink biotite muscovite granites, rather distinctly foliated. A very light gray gneiss is seen on the north side near the portage on the route to Pooh-Bah Lake, in which the alternate bands of white and dark gray rock are uniform, and the laminæ much distorted; the bands in which the biotite predominates are comparatively far apart and give the rock a streaked aspect.

McIntyre
Lake.

On McIntyre Lake the granites are rather fine-grained, deep pink, and indistinctly foliated; the same rock is seen on Sarah Lake. On an island at the east end of the latter the granite is darker in colour, and affords macroscopically distinct evidence of having been sheared.

Graphic
quartz.

A peculiar graphic granite is seen at an exposure at the north end of the small lake south of Sarah Lake, where a red felspar, in medium sized crystals, is associated with irregular grains of quartz; this is intersected by veins and stringers, less than half an inch in thickness, of pure quartz; these little veins as a rule are roughly parallel in a general north and south direction, but sometimes veins intersecting these at various angles are seen.

Keefer Lake
route.

The rocks of the second lake north of Keefer Lake, south of Shelley Lake, are in places doubtfully biotite granite, the bi-silicate now existing as a chloritic mineral which may have been derived from hornblende. Comparatively large imbedded crystals of orthoclase give the rock a porphyritic aspect.

Most of the rocks of this route are reddish biotite granites somewhat obscurely foliated.

Chloritic
granites.

Chloritic granites are associated with the biotite granites of the first lake north of Keefer Lake, and on the west side of Keefer Lake, about the middle; here the rocks show crushing and shearing phenomena, and it is probable that the chloritic mineral has been derived in this way from mica.

The shores of Kahshapiwigamak Lake are rather high and abrupt, and present continuous exposures of granite, reddish in colour, and fine-grained, containing, as a rule, but a small proportion of mica, and none at all in several places in the southern part. In the rocks of the north-eastern arm the bi-silicate is now a chlorite, and they contain some porphyritic twinned crystals of felspar. The rock is deep red in colour. On an island near the west shore, north of the centre of the lake, the granite contains a little muscovite, probably secondary, as the rock exhibits crushing and shearing phenomena. The chloritic phase of the granite is seen on the west side of the most easterly of the two bays at the south end. Pegmatite with muscovite is seen in the northern part of the lake.

The shores of Hulbert and Williams lakes, with those of the other Hulbert Lake route, lakes forming this route, are high, rugged and precipitous, presenting bold, sometimes perpendicular, cliffs, seen to be composed of granite, containing as a rule a small proportion of mica. The rocks are gray or reddish-gray in colour and coarse in texture. The lamination is very indistinct, often indescernible in the hand specimen, though foliation is often quite apparent in the field. Biotite pegmatite occurs about the middle of the lake south of Kahnipiminanikok Lake.

The granitic rocks of Kahnipiminanikok Lake may be generally described as light pinkish-gray, medium-grained biotite granites, usually somewhat distinctly foliated. Their character is comparatively uniform in all parts of the lake, and presents no novel features beyond those already referred to. In the bay on the north side of the lake one mile west of McKenzie Inlet, some of the largest crystals of orthoclase known in this country, occur, some of them measuring four inches in length. Iron pyrites occurs in the granites of the north end of the lake. Muscovite-biotite-pegmatite occurs on the north side near the mouth of McKenzie Inlet.

The granites of the northern part of Agnes Lake, are on the whole a pinkish-white or light gray biotite-granite-gneiss generally quite distinctly foliated.

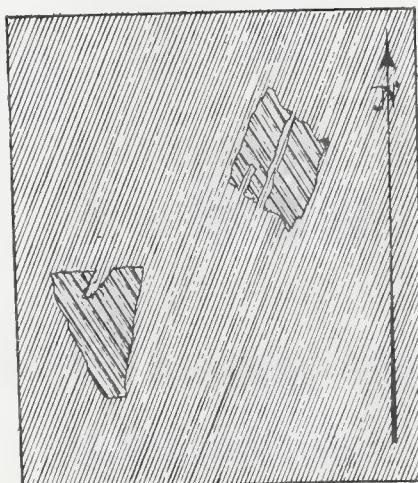
A curious example of patches of foreign rock included in the granite, is seen on the bare hill on the east side of the little bay forming granite. the southward extension, behind the spur running north of the large bay running north-east from about the middle of the lake.

The country rock is a pink foliated granite gneiss, dipping S. 70° E., angle 45° . There is a faint appearance of bedding in planes parallel to this. Imbedded in this are the fragments, figured here, which consist of a dark gray micaceous gneiss or mica schist, with a greenish tinge, probably due to a partial decomposition of the mica into chlorite.

The lamination of the gneiss abuts sharply upon the outlines of the fragments, and continues into the little dikes which cut into the fragments, as shown. These dikes are parallel to the direction of the lamination.

Rocks of
Kahnipimin-
anikok Lake.

Fig. 2



The surfaces of the inclusions have a regular ribbed or fluted appearance, the ribs being two or three inches apart and standing nearly an inch above the trough-like depressions. These ribs are parallel to each other, and their direction in different inclusions are also roughly parallel; they also mark the direction of the planes of schistosity of the mica schist (which is not, however, very fissile), cross that of the lamination of the inclosing gneiss, at an angle of about 50°.

It will be observed that a line drawn from this locality, north-east, ^{Synclinal axis.} parallel to the lines of strike shown on the map, would strike the schistose band of McEwen Lake, and the inference is strong that these inclusions mark a synclinal axis in the once overlying Couthiching rocks, which, save only these fragments, have been entirely denuded.

The rocks on the south part of Agnes Lake, for the most part obscurely foliated red granites and felsites, have nearly all been incidentally described in previous pages.

^{Pegmatite.} A pegmatite, containing no mica, is seen on an island in the northern part of the lake, thirty chains south of the mouth of the narrows through which the eastern outlet passes. A little iron pyrites is here associated with it.

^{Agnes Lake to Basswood Lake.} The rocks exposed on the route from the middle of the west side of Agnes Lake, are for the most part reddish medium-grained biotite gneisses. Near Basswood Lake, they usually contain a little bi-silicate, which is now principally changed to chlorite. The foliation is generally apparent, but rarely distinct. In some places they are lighter in colour and are banded with dark gray varieties.

^{Remaining portion of area.} All the rocks east of this, comprising the Hunters Island area, may be generally described as pink gray, medium-grained biotite granite gneisses, usually foliated with more or less distinctness; they present no varieties which require special mention.

Hornblende Granites.

^{Stratigraphical relations.} As yet no specific mention has been made of the hornblendic variety of granites occurring in this area. The writer has not studied the relations of these to the mica granites sufficiently closely, or extensively to enable him to formulate any general observations thereon; while it is probable that they are but phases of Laurentian rocks, and that they possess no stratigraphical importance, it is on the other hand possible that some general law giving them a distinct significance may be deduced and that they may be shown to differ both in origin and age from the ordinary biotite

granites. For the present, only some of the localities where they are found in the Hunters Island area can be indicated.

A small area of hornblende granite or syenite is seen on the portage Brent Lake, at the south-east end of Brent Lake. The same rock is exposed on the south portage at the west end of Conmee Lake. The area is here a Conmee Lake, small one and would seem to be an inclusion in the biotite granite. Similar rocks are seen on the west shore of the lake, south of the Couthiching belt of rocks.

Hornblendic granite is associated with the biotite granites of the lake north of Keefer Lake.

A band of red coarse-grained hornblende granite, containing porphyritic crystals of felspar, perhaps triclinic, occurs on the east shore of the north-east arm of the lake south of Hulburt Lake, a quarter of a mile south of the portage into that lake; it is again seen half a mile S.S.W. on the south-east bay of the same lake. It has here a direction of S. 35° W., indicated by its foliation, which is in some places quite apparent. A probable southward extension of this band, is represented by a band of very similar rock occurring a mile S.S.W. of this, skirting the east side of the north-east arm of Kashapiwigamak Lake, near the portage between the two lakes. The strike is here S. 40° W., dip N.W., angle 75° . A still further south-westerly extension may be represented by an occurrence of a similar rock, containing, however, a smaller proportion of hornblende, seen on the small island at the mouth of this arm; here the direction of the foliation planes is uncertain but appears to be about S. 10° W. A narrow band not over two chains wide, of a rock which answers to the same description, but which contains a mica constituent, is seen cutting the red indistinctly foliated biotite granite, starting from the west shore of the lake south of Hulburt Lake, due west of the first granite band referred to, on this lake, and is traced through the narrows, and, then with a more northerly trend it crosses in a north-westerly direction, the north-west arm of the lake. These two bands converging on the same point are suggestive of dikes emanating from a central mass, and may be altered post-Laurentian eruptives. Associated with both these diverging bands are narrow bands of fine-grained dark gray siliceous, micaceous, hornblende schist.

Diverging bands.

On the south-west bay of Agnes Lake, a considerable proportion of Agnes Lake. hornblende granite is associated with the foliated biotite granites. The whole of the southern part of the bay is occupied by these rocks, while a small area, probably a comparatively narrow band, is seen on the west side, just opposite the point dividing this bay from the main lake; here the rock is faintly laminated, and there appears

to be a sharp line of demarcation between it and the biotite granite, although some of the associated rocks contain both hornblende and mica. In some places the hornblende granite appears to be included in the biotite granite or felsite.

Fine-grained red hornblende granite, sheared and containing some biotite, is seen on an island near the east side of Agnes Lake, two miles and a half S.S.E. of the point above referred to, and south of this on the west shore similar rocks are occasionally seen.

Farquier
Lake.

In the north-west bay of Farquier Lake, the granite is massive and very dark, and exhibits in the fresh fracture small inclosed masses of hornblende.

Murdoch
Lake.
Kahnipimin-
anikok Lake.

Gray medium-grained hornblende granite occurs on an island in the north end of Murdoch Lake, and in Kahnipiminanikok Lake, at the entrance to the bay north of Murdoch Lake.

McKenzie
Inlet.

On the south side of the eastern end of McKenzie Inlet, the prominent points consist of large flat blocks of medium-grained hornblende granite; west of this on the north side of the narrows, a similar rock, but finer grained, occurs *in situ*, being apparently a band a few chains wide; the same rock is exposed at three or four localities due west of this, on the west shore. On the extremity of the prominent point on the south side of this inlet, a mile and three-quarters north north-east of the entrance, a local occurrence of coarse-grained sheared hornblende granite is seen, in which the hornblende has been largely changed to chlorite in the shearing planes.

Kahwavia-
gamak Inlet.

On the arm south-east of this, at the narrow part halfway between the main lake and the Indian reserve, a local occurrence of fine-grained hornblende granite is seen on an island in the centre; on the north shore opposite this a little biotite is associated with it.

South-east
part of lake.

On the south-east part of this lake, on the north side, about the middle, is an irregular band of fine-grained hornblende granite, which, in the most westerly exposure examined, becomes a fine-grained, felspathic, dark gray hornblende schist, containing apparently a pyroxenic constituent.

Wet Lake.

At the outlet of Wet Lake, on the north side, the rock consists mainly of hornblende, considerable mica, a little flesh-red felspar and perhaps a little quartz; on the north side of the lake, about the middle, a narrow band having the aspect of a dike of hornblende syenite occurs.

McEwen
Lake.

On the northern extremity of the island in the east bay of McEwen Lake, and opposite it on the north shore, a medium-grained dark red micaceous hornblende granite occurs; the same rock occurs on the

point at the extreme south end of the lake. These occurrences would seem to mark a continuous band or dike of these rocks.

Continuous
band of horn-
blende granite

At rare intervals a bedded structure in the granite is discernible. The beds are usually not much less than a foot thick, and seldom more than three feet thick, and are generally parallel to the foliation planes of the rock. From later observations made elsewhere, it may be stated as a general rule, that the hornblende granites exhibit this feature much more commonly, in proportion to their development, than the biotite granites do; but in hornblende granites the writer has nowhere seen a distinct lamination of the mineral constituents, associated with this structure.

Bedded
structures.

Some of the localities where this apparent bedded structure was observed may be briefly enumerated:

Localities of
bedded
structure.

On Kahnipiminanikok Lake, on the north side of the bay on the south side of McKenzie Inlet, beds from a few inches to a foot thick inclined to the south-west at angles varying from zero to 15° are seen.

Kahnipimin-
ani kok Lake.

On Agnes Lake, on the east side, near the north end, the planes dip to the north angle 10° to 15° , foliation planes which strike N. 30° E and are nearly vertical intersect these beds.

On the east side of Agnes Lake, near the entrance of the north-east bay, the beds dip N. 60° W., angle 30° . On the opposite side, near the north end of the bay, the beds are parallel with the lamination planes.

Two localities in the red granite of the east shore of the lake, about the middle of the southern part.

On the south-west end of Farquier Lake are rough irregular beds in red granite, inclined N. 70° W., angle 50° .

Farquier
Lake.

On Sunday Lake, south part, beds inclined S., angle 60° .

IV. SAGANAGA AREA.

The rocks of Saganaga Lake and vicinity were not examined by the writer who is, therefore, unable to make any definite statements regarding their character, or to do more than state the grounds on which they have been tentatively represented on the map as Laurentian. These reasons will be given later.

On the geological map of the Dominion of Canada, published in 1882, the granitic rocks of Saganaga Lake are represented as igneous granites breaking through Huronian strata. On the "Geological map of the Iron Regions of Minnesota," published by N. H. & H. V. Winchell in 1890, they are represented as Laurentian. The rocks are

Winchell's
description
of rocks.

described by the above authors in the accompanying report as "receiving a distinctive character from the large grains of quartz. These grains are large, angular and numerous, and on weathered surfaces stand out prominently. The felspar exists in sub-angular patches, imbedded with the quartz in a ground-mass, which is mostly chloritic and in places develops chloritic spots, while in other places hornblende forms merge into visibility." Again they say: "The rock itself is not of course a characteristic syenite. All hornblende has disappeared; a felspathic matrix remains, with some green specks and spots, and the quartz is imbedded in it. Some of the broken surfaces of the rock have a sericitic lustre. The formation as a whole is roughly bedded." From this they would appear to be allied to the quartz porphyries.

H. V. Win-
chell's later
description.

H. V. Winchell,* in a later paper on the subject, dated December 20th, 1890, says that "the rock is conglomeritic in places, and contains pebbles which are strikingly similar to each other in composition and appearance. A majority of the pebbles are composed of lamellar augite, with or without apparent small grains of felspar."

V. ISOLATED GRANITIC AREAS.

Breaking through the Cutchiching rocks of the region, are isolated areas of granite, which cannot certainly be said to be of Laurentian age, but it would seem that the balance of evidence favours that view.

Granite area
north of
Namakan
Lake.

By the Soldiers' Portage route, above referred to, between Namakan and Rainy Lakes, there are two portages; on the south-easterly one felspathic mica schist is frequently exposed; on the slough and on the other portage (Soldiers' Portage) massive granite is exposed, as well as on several points of the southern extension of Hale Bay, and on the island in the angle of it. These exposures indicate the existence of what is probably an isolated local area, similar to those shown on Hale Bay and on the southern shore of the eastern arm of Rainy Lake, west of Kettle Falls (see Rainy Lake sheet). This granite is deep red in colour and not at all foliated; it would appear to be a distinct intrusive mass.

Thompson
Lake granite.

The granite of Thompson Lake is an isolated area, being cut off from the main mass to the south by the band of mica schist indicated by the almost continuous exposures along the south shore of the lake. The exposures in the eastern and western extremities of the lake, and along the canoe route north, prove this area to be surrounded on all sides by mica schist. The contact is brecciated, and is typical in character of that of the large Hunters Island area to the south. On the north-west,

*Am. Jour. Sc., vol. XLI., No. 245, p. 386. 1891.

north and east sides, the schists, wherever observed, were found to dip away from the granite nucleus at angles varying from 40° to 60° , but there is no evidence of a synclinal structure between this and the granite apophysis to the south.

The granite boss on Wolseley Lake is inferred from a few exposures ^{Wolseley} _{Lake granite.} on the peninsula and adjacent islands. Its limits could not be exactly defined, nor its contact with the schists observed, owing to the drift covering by which it is concealed.

Small outcrops of granite in rocks of presumably earlier age, are seen in many localities, particularly in proximity to the large granitic areas, and as these areas are approached the increasing abundance of granitic mica schist. bands marks the contact zone. Such small areas and isolated bands, more or less distant from this zone, and too insignificant to be shown on the scale of the map are found in the following localities :—

Captain Tom Lake, about the middle of the north side.

^{Captain Tom}
Lake.

On the creek east of the portage south from Tanners Lake, reddish fine-grained evenly foliated biotite gneiss.

^{South of}
Tanners Lake.

On the outlet of Darkey Lake. Several small outcrops perhaps marking an anticlinal axis. Medium to coarse-grained and pegmatitic muscovite granite. Biotite is sometimes associated, and in one exposure, garnets are seen.

Near the mouth of the stream forming the outlet of Pooh-Bah and Wink lakes.

On the portage north of Conmee Lake.

^{Conmee Lake.}

On the small lake, north of Conmee Lake, at the west end. This same band apparently occurs on the south side, near the north-east end ; but here it is very coarse-grained, the larger crystals of the felspar are twinned, and a little hornblende is perhaps present.

A small area of muscovite granite is seen associated with the mica schists of the west end of William Lake.

GENERAL THEORETICAL CONSIDERATIONS.

In the foregoing pages, doubts have been expressed as to the age of some of the so-called Laurentian areas, notably the Pooh-Bah syenites, the Saganaga granites, and the small areas of eruptive granitic rocks.

Any attempt to reconcile the various diverging theories regarding the Archæan rocks, is perhaps premature and can only be suggestive.

The Laurentian rocks of the eastern part of the Dominion, as described by the older Canadian geologists, and corroborated by the observations of later workers, point to the conclusion that many at least of these granite gneisses are sedimentary in their origin.

Eruptive granites of the western portion.

Theory accounting for brecciated contact.

Objections to the theory.

Irruptive origin not certain.

In this western portion, the work of Dr. Lawson, in the Lake of the Woods and Rainy Lake regions, the observations recorded in this report, and the observations made by other workers in contiguous fields, indicate, with equal strength, that here the granites are eruptive in their attitude and relationship to the overlying rocks.*

It has been argued that while the Laurentian rocks as a whole may have been sedimentary in their origin, the brecciated character of the contact with overlying series may have been caused by later granitic eruptions along this line, which would be emphatically the line of weakness. This is a possible, though not probable, explanation of the facts ; not probable, because no distinction can be drawn between the granites at the contact and those in the central portions of the great granitic areas, save that of a gradual change from a gneissoid character at the contact to a granitoid one in the centre, as a rule, and this is not the change that would be expected between a sedimentary nucleus however metamorphosed and a granitic periphery however foliated by flowing movements while in a liquid or viscid state. Again no line of demarcation between the supposed sedimentary rocks of the interior and the assumed newer granites of the periphery, which also cut the upper Archæan schists, has, within the writer's knowledge, ever been described. It must be acknowledged, however, that in such old and changed rocks, negative evidence is especially inconclusive.

The question of the irruptive origin of all the granites of this Lake Superior region cannot yet be answered with absolute certainty. It would be rash to state from the comparatively local examinations that have yet been made, that the contact is always of an irruptive character, although in many cases it must undoubtedly be so regarded. It would be equally rash to state that the nature of the contact is nowhere compatible with a sedimentary origin for the granite gneisses ; minute and irregular interbanding is not an uncommon feature in the transition zone between contiguous formations of rock unquestionably sedimentary.

*Having personally examined both the eastern and the western Laurentian areas at intervals, from the Straits of Belle Isle to Ottawa, and thence to the Lake of the Woods and Lake Winnipeg, I am convinced that whatever theory of origin may be correct, it is equally applicable to the whole of the great Archæan area of Canada. The local greater or lesser development of some special lithological character, as limestone, quartzite, etc., or physical structure, as gneiss, granite, mica, schist, etc., has no more bearing on the question of age, than have the similar local peculiarities which are more or less characteristic of all the younger geological systems, as for instance, the Cretaceous of Britain and of Canada ; the lower palæozoic of Canada, and of Southern Australia ; and even within the limits of the Dominion, the upper palæozoic rocks are both lithologically and physically more unlike each other than are any of those of the great Archæan area from Labrador to Winnipeg, and thence to the mouth of the Mackenzie in the Arctic Ocean.

A. R. C. SELWYN.

In the previous pages localities have been cited where an apparent bedded structure in the granite gneisses is more or less marked. This feature occurs at very rare intervals, and is extremely local in extent, wherever observed ; the inclination of the bedding planes are generally, though not always, parallel to the lamination planes, where these are discernible ; and the rock at the planes of parting does not present any of those changes in composition which so frequently mark the bedding planes of sedimentary rocks ; from these facts it seems highly improbable that this apparent bedded structure indicates a sedimentary origin. It is probably caused by the accidental yielding of the rock in parallel planes under the various strains to which it has been subjected. Nor can the foliation and lamination discernible in these gneisses be regarded as indicative necessarily of sedimentary deposition.

Between the Laurentians of the Ottawa Valley and of Western Ontario, there is one marked difference, the presence of a series of limestone in the former, and its comparative absence in the latter ; but the absence of a lithological member of a series, as limestone or quartzite, does not militate against the correlation of the members occurring in different districts, and future investigation may prove the Cutchiching series to be the stratigraphical equivalent of the Upper Laurentian series of the east, to which as far as may be gathered from published descriptions of the latter the mica schists would seem to bear a marked resemblance in stratigraphical relationship. But whatever conclusion may be eventually arrived at regarding the origin of Laurentian rocks, or whatever subdivisions of, or rearrangement of certain members of this system future investigation may justify, the separate areas of granitic rocks referred to in this report present no individual characteristics sufficiently significant to justify the belief that any great difference exists between their respective ages, and the same theory of origin that applies to one applies to all. The smaller granitic areas of this region present no difference in lithological characters or in stratigraphical relations from those of the large areas which have been called Laurentian, such as to justify us in regarding them as of later date ; and it seems most probable that they are subordinate developments of the same fused rocks, marking the crests of anticinal domes or folds in the intensely and minutely folded crust.

H. V. Winchell regards the Saganaga Lake granitic rocks as of Keewatin age from their lithological character, from his discovery of a small band of chalcedonic silica in the syenites, and from their frequent alternation in bands with Keewatin schists. From the title to his photographs given by Dr. Lawson, he evidently regards these rocks as Laurentian. As before stated, the writer is not in a position

to express any opinion on the subject, but he has mapped them as Laurentian in accordance with Dr. Lawson's opinion, and from the character of the contact as shown by his photographs and reproduced in plates I., II. and III., which seems to be typical of the contact of lower and upper Archæan rocks elsewhere in this region; and also because they seem to form an integral part of a granitic area, which, from what is known of its more eastern development, would seem to be more undoubtedly of Laurentian age. The portion of this area in this sheet is trifling in extent, and in working up the region embraced in the sheet east of this, the rocks will receive closer and more conclusive study. In the meantime it would seem safer to map them as Laurentian.

Pooh-Bah
area.

The Pooh-Bah syenites differ in lithological character and in the nature of their contact, so far as can be determined, from the typical Laurentian biotite granites, but these differences are neither so marked nor so important as to offer any serious obstacle to the correlation of them with the Laurentian. In mineral composition they are typical of the quartzless hornblende syenites, which have always been regarded as a species, although a rare one, of Laurentian rocks; and they are not more coarsely crystalline than the pegmatitic phases of these rocks.

In comparison with the whole length of the periphery of the area, so little of it has been available for study, that it is hazardous to make any statement concerning the general nature of the contact, and though where the rocks are revealed sufficiently near the line of contact to allow its nature to be guessed at, it would seem to be unusually sharp and clear, this fact, in itself, has little significance. The mica schists appear to have suffered more than usual contact metamorphism; but on the other hand, the syenites reveal no differentiation from a coarse texture on the central portions to a fine one at the contact, indicating that they were intruded into cool consolidated rocks; and they would seem to have cooled very slowly and uniformly, such as deep seated subcrustal irruptions would be expected to cool.

The correlation of the hornblende rocks, between William and Brent lakes with these is at best a doubtful one, and while the field appearance of the former suggests that they were erupted at a later date, it by no means proves it.

In the absence of conclusive field evidence, we are again thrown back upon their lithological affinities with certain phases of Laurentian rocks to decide, for the present, the question of their age.

COUTCHICHING SERIES.

Limits of area and conditions of contact with lower rocks.

The Coutchiching series of rocks, which is so largely developed in the south-eastern part of the Rainy Lake sheet, extends into the north-west part of this sheet in a broad tapering area, whose outline will be now briefly defined.

Passing up the channel above Kettle Falls (see Rainy Lake sheet) into Namakan Lake, where the channel bends sharply to the south, evidences of an approach to a granitic area is seen in the banded intrusions of granite into the mica schist; these intruded bands become more and more numerous and important as we proceed southwards, until when we reach the long narrow island, three-quarters of a mile south of the expansion of the channel into Namakan Lake, we find on the southern part of this island that the granitic rocks are decidedly the most abundant, while on the north part of the island the mica schists still seem to maintain their predominance, for this reason the line of contact is placed across that part of the island where the two rock species appear to be most equally developed. East of this island, along the north shore of the lake, the exposures are sufficiently numerous to admit of an approximate delineation of this line of equal development, as indicated on the map. The brecciated contact zone appears to become a little narrower. North of this conventional line the predominating rocks are medium grained felspathic mica schists, gray in colour; south of it massive pink granites, doubtfully if at all foliated, form the material of the widest and most numerous bands.

From the bay south of Hale Bay (see Rainy Lake sheet) to the Soldiers' Portage route. middle of the north side of Namakan Lake, there once existed, probably but a short time since, a subordinate channel between these two sheets of water; it has become choked with boulders and drift and exists now as a narrow slough, between the north-western end of which and the bay south of Hale Bay the Soldiers' Portage is cut, while a shorter portage connects the south-east end of the slough with Namakan Lake.

Less than half a mile south south-west of this latter portage, the line of contact of the mica schists and granites can be fixed with great accuracy, from the close proximity of adjacent exposures of the two rock varieties and from the comparatively unbroken character of the two series each side of this line. From here the contact line sweeps to the south-east and passing through the centre of the lake crosses in an east American direction over to the American islands, and cuts across the side.

small peninsula to the south-west of the boundary line at the Narrows into Sand Point Lake, and appears again in Canadian territory on the south side of the bay north-west of David Lake.

Minnesota
band of
granite.

The contact thus far traced, marks the northern limit of the great development of granite gneisses shown on the geological maps of Minnesota.

Sand Point
Lake.

In the bay of Sand Point Lake, north-west of David Lake, the junction can be seen on a narrow point forming a shallow bay of the south-east shore of this arm. The contact is next located in the south-west corner of David Lake; it cannot be placed here within a few chains.

David Lake.

On the west shore of the lake the granites are frequently exposed, containing thin bands and irregular patches of mica schist. A single exposure of granitoid gneiss on the north-east shore of the lake, one-quarter of a mile north-east of the point about the middle of this part of the shore, probably marks the eastern limit of the granites. The point is occupied by a soft light gray evenly laminated gneiss, doubtless Coutchiching; the same rock is exposed near the outlet on the south shore; these exposures probably belong to a transition zone between the granitoid gneiss of the west shore, which, near the outlet, is distinctly foliated, and the mica schist exposed on the extreme eastern shore of the lake in one locality. The line of contact, therefore, would appear to strike from the north-west corner of the lake to touch the north-east shore, at the granite locality indicated above, then to turn sharply to the south and south-west under the waters of the lake and pass through the channel forming the outlet into Sand Point Lake, between the foliated granites, containing thin bands and patches of mica schist exposed on the north side of the channel, and the mica schist and fissile light gray gneiss frequently revealed on the south side. This location of the line of contact is supported by the strikes which are everywhere observed to be in conformity with such a line. The contact is seen on the point of the south shore, just west of the outlet of David Lake, and must pass very close to the north-west shore of the bay south of this point, as the rocks here consist of alternating bands of granites and mica schists, the former predominating, while there are several exposures of uninterrupted mica schist on the east side of the bay. The strike of the rocks on both sides of this bay are parallel to the shore line.

Contact curv-
ing to south-
west.

From here the line of junction evidently strikes south-west, in conformity with the strike of the rocks, to the north-east shore of the southern expansion of Sand Point Lake. Although it can be here approximately located, the actual contact is concealed under the marshy shore. On the shore to the south and on the islands the mica schists

Sand Point
Lake.

are frequently exposed, and from the curvature of their strike, and Contact curves again from the occurrence of granitoid gneiss on the American side of the to south-east. channel, it is evident that the junction line sweeps to the south and then to the south-east, under the waters of the lake.

The schists, in this part of the lake, dip away from the granite at Low dips. unusually low angles, in one locality as low as 17° . From Sand Point Lake, the contact line has a still more easterly trend, and is located with considerable accuracy in the northern bay of Little Vermilion Lake. Little Vermilion Lake.

From here it must strike generally east, then north-east to the south side of the bay of Lac la Croix, out of which the old Nequaquon portage leads. The mica schists of this bay are much invaded by granites, and the point on the south side of its narrow inlet is entirely occupied by the massive granite, indicating either a sharp twist in the line of contact, or an invasion of the granites across the strike of the schists, as the contact west of this point and east of it on the opposite side of the bay can be located with much precision. Lac la Croix.

The schists show considerable variation in their strike, but dip away from the granites at angles varying from 35° to 45° , in a northerly direction. In the northern extremity of this bay, is an exposure of massive granite which would appear to belong to the same mass as that exposed in the first portage going north from Lac la Croix to Thompson Lake, and on the long portage, further east, leading directly between these two lakes; and this granite appears to be an apophysis Granitic from the main mass of granite exposed on the adjacent islands and on the apophysis. American shore. There is no evidence that the band of schists, above described, continues sufficiently far east to separate this tongue of granite from the main mass, although the granite on the islands to the south, includes narrow bands of schist. The dip of this band of schists is uniformly to the north at a fairly constant angle, viz., 45° , and there is no convergence of dip to indicate a possible synclinal structure in this band.

From the north-west corner of the bay, in which on the map is shown the line of junction of the northern edge of the apophysis, the contact line appears to bend sharply to the south south-east, and then to strike a little south of east through the islands, and to skirt the American shore, until it is seen again in Canadian territory on the northern part of Roland Island; in this distance, the brecciated contact zone seems to Roland Island be unusually broad, alternating bands of mica schist and granite being exposed on all the American islands, along the Minnesota shore.

Through the south-eastern part of Lac la Croix, the topography was taken from the surveys of Mr. David Thompson, and the geological boundary was determined by Dr. Lawson.

Wicksteed
Lake

Between here and Wicksteed Lake the contact was not actually traced, but it lies between the extreme north end of McAree Lake, and the southernmost outlet of Maligne River, and it is drawn in conformity with the strike of the rocks. On the north-eastern side of Wicksteed Lake, the contact is marked by a zone of alternating bands of granite and mica schist, which is here somewhat narrow, being about three or four chains in width.

Darkey Lake.

The numerous exposures on the shores and islands of Darkey Lake, enable the distribution of the rocks to be mapped with considerable precision. All along the northern shore, fine grained, brownish-gray mica schists are exposed, invaded by some bands of pink muscovite granite gneiss; going south down the east shore, there is a broad zone of alternating bands of mica schist and gneiss, and along the north shore of the outlet of Brent Lake, the granites preponderate, and on the south shore of this inlet they are almost entirely unbroken by schistose bands. These granites (fine-grained muscovite biotite) can be traced on the shore of Darkey Lake south. This would appear to be an apophysis of granite, as it is divided from the main mass by an unbroken band of dark gray felspathic mica schist exposed further south on the east side of the lake. The probable eastern extension of this band is exposed on the south-west shore of Brent Lake as a somewhat narrower band. This band has no extension westward, but on the portage into the small lake lying west of Darkey Lake, is an exposure of mica schist striking about N. 30° W., with a comparatively low north-easterly dip, which probably marks its western termination, as no considerable isolated band of mica schist occurs on the shores of Wicksteed Lake. The strike above given probably indicates a sharp horizontal fold in the mica schists lying between the main granitic mass to the south and the apophysis to the north.

Granite
apophysis.

Band of mica
schist.

Brent Lake.

Granite
apophysis.

The tongue of granite frequently exposed in the channel forming the outlet of Brent Lake, is not seen to extend further east than the west shore of Brent lake, where a single granite exposure is found a few chains south of the outlet. Along the south-west shore, for half a mile, the mica schists of the band described as terminating in Darkey Lake are exposed. They dip northerly at a low angle. The point forming south of it the small bay in the extreme southern part of this part of the lake, is composed of granite; this indicates the existence of another small granite apophysis, as the south and east shores of this bay afford numerous exposures of mica schist, somewhat hornblendic in character.

On the portage, and in the little lake south of this bay, however, massive red granite, containing very little bi-silicate, is exposed. On the north-east shore of the bay the same mica schists are exposed, in-

vaded by narrow bands of granite; these occur all along the south shore of this south-western portion of Brent Lake. The little bay to the east affords one exposure of granite, on the south shore; which probably marks the northern limit of the large granitic area. The eastern end of the bay is marshy, but on the north shore and through the main channel to the north, massive gneiss, reddish in colour, and somewhat distinctly foliated, occurs.

The band of mica schist to the south, therefore, is about ten chains wide where it is last seen on this lake; its continuation to connect with the band, probably about the same width, of brownish and dark gray siliceous felspathic mica schist, seen on the north side of McIntyre Lake, is conjectural, as also is the continuation of this band south-eastward; but whether continuous or not, the band shown on the map probably indicates the position of the axis of a synclinal fold, of which these exposures are the pinched in remnants.

The band on McIntyre Lake contains intermediate bands of granite, and dips N. by E., angle 40° to 45° , over the granites on the south and under them to the north. The granites are deep pink in colour, faintly foliated for the most part, and contain chlorite.

Returning to the south-western part of Brent Lake to trace the northern boundary of this band, we find exposures of mica schist at the two points at the entrance to the most easterly of the two bays running north, and again striking along the western shore of this bay, while the eastern shore is occupied by granites. Along the eastern shore the bare hillside slopes about 35° to the west; on the surface are seen many flat scaly inclusions of crumpled micaceous schist. This would seem to be a surface of contact between the underlying granites and overlying Cutchiching rocks, and the appearance is strongly suggestive of the eruptive character of the former. The line of contact appears, therefore, to sweep sharply to the north up this bay. The contact in the northern end of the bay is concealed by drift; but on the south side of William Lake, it can be closely located, and by the few exposures of schist on the north side of the east end of this lake, and the few granite exposures on the south side, is determined as lying under the waters of the east end of William Lake; thence it can be again somewhat closely located, on the west shore of Conmee Lake, by the exposures occasionally outcropping along the low marshy shore.

Through Conmee Lake, the contact is determined as lying between the brownish-gray mica schist exposed all along the north shore, and the off-lying islands, which consist of medium-grained, dark gray granite, containing hornblende and biotite, and banded with subordinate bands of mica schist.

Bands of
mica schist.

On the south side of the lake, is a series of narrow but persistent bands of mica schist, striking generally about S. 80° W. and dipping northerly at angles varying from 30° to 45° . On the bay running to the south, at the east end of the lake, is a band occupying the whole of the island, at the mouth of the expansion and traced on both shores; the band curves from S. 30° E., on the west, to S. 60° E. towards the east, with a north-easterly dip of 30° to 40° . This band appears to taper off to the south-east, but its extension to the north-west cannot be seen on the south-east shore of the main lake, and it would appear to be a comparatively large isolated lenticular band.

Possible un-
conformity.

The general strike of the foliated granitic rocks on the south-east side of the lake, gradually changes from S. 80° E. near the west end, to S. 20° E. near the east end; while the strike of the mica schists on the north side, varies between N. 65° E., and N. 85° E. This would appear to indicate a structural unconformity between the two series. One or two strikes obtained near the contact, indicate that the strike of the gneisses bends sharply round, in conformity with the structural planes of the schists, but as the line of contact is mainly concealed under the water, there is not sufficient evidence to establish whether there is here an unconformity or not. While the varying directions of the structural planes of the Laurentian and Couthiching rocks may be explained by assuming the existence of a fault, there is no independent evidence at hand in support of this assumption.

The most easterly point where the contact is determined is on the south-eastern shore near the eastern end of Conmee Lake.

Distribution
east of Con-
mee Lake.

The distribution of mica schists in the area between Conmee and Keefer lakes, owing to the inaccessibility of the country is conjectural, but is based on facts which will be given below.

Lake north of
Keefer Lake.

A band of fine-grained, dark gray siliceous, hornblendic mica schist is seen on the lake north of Keefer Lake, on the bay running to the north-west. From the exposures on this bay, the band must be over half a mile wide, but its western boundary was not determined; it is interrupted by parallel granitic bands, of subordinate width. Presumably, the northern extension of the same band, is seen on the stream forming the outlet of these lakes, and is traced closely and accurately to the north end of Kahnipiminanikok Lake, where it is about half a mile wide. These schists contain so much hornblende, as to leave some doubt as to whether they are not Keewatin in age, but lithologically they are perhaps more closely allied to the Couthiching hornblendic mica schists, than to the Keewatin micaceous hornblende schists. The presence of hornblende, even in predominant quantity, cannot be taken as conclusive evidence of age, in the face of opposing stratigraphical pro-

Kahnipimin-
anikok Lake.
Hornblendic
schist.

bilities, and for this reason I have mapped them as Coutchiching, considering the presence of hornblende to be a local and not significant facies.

The mapping of this band of rocks in continuation with the mica schists north of Connée Lake, is inferred from the structure of the granites on the lakes surrounding this area. An examination of the strikes and dips of the foliated portions shown on the map, will show that with local variations the general strike of the rocks is rudely parallel with the general trend of the watercourse, from the small lake south of Keats Lake to the ultimate outlet of these lakes into Sturgeon Lake, viz., from south-west with a north-west dip south of Keats Lake, to north-west with a north-easterly dip on the south-east arm of Sturgeon Lake. On Brent, McIntyre and Sarah lakes, particularly the two latter, the rocks are granitoid and exhibit very little foliated structure, which, however, may be regarded as parallel to the general trend of the watercourse, which curves from E. by S. on Brent Lake, to S. by E. on McIntyre and Sarah lakes.

The general trend of Keefer and Kashapiwigamak lakes indicates roughly the direction of the structural planes of the surrounding rocks, which is S.S.W. or S.W. by S.

Such dips as are observable, are northerly, at a high angle, on the triangular lakes south-east of Sturgeon Lake; north-easterly, at a comparatively low angle, on Brent, McIntyre and Sarah lakes, and westerly, at a comparatively low angle, in Keefer and Kashapiwigamak lakes, viz., if we regard the high inclination of the rocks on the north as representing overturned dips, all inward towards a triangular central area, which represents probably a triangular trough in the Laurentian rocks, in which would very likely lie the south-eastward extension of the rocks north of Connée Lake, and the south-westerly extension of the micaceous schists seen on the lake north of Keefer Lake.

A southerly tapering extension of the trough would probably be involved by the folding above assumed which would extend roughly parallel to Kashapiwigamak Lake.

Attenuated anastomosing bands of upper Archæan rocks, surrounding nuclear areas of granite are so common a feature in these azoic rocks, that coupled with the suggestion offered by the structure of the surrounding granites, the general correctness of this mapping would seem highly probable.

The south-western boundary of the northern central area of granites, probably swings round from the north-western edge of the band of mica schists, revealed in the lake north of Keefer Lake, in general conformity with the trend of the watercourse of the lakes draining into the

South-western limit of central northern granite area.

Contact on
Sturgeon
Lake.

south-eastern part of Sturgeon Lake; first westerly, then north-westerly, thence northerly and north-easterly, to the point where it is again accurately determined in the narrow channel between the eastern and south-eastern expansions of Sturgeon Lake, where the usual brecciated contact zone is seen between the fine grained gray muscovite biotite granite and the mica schist. The contact is placed where the included bands of mica schist become predominant in quantity. From here on the west shore to the mouth of the small creek half way to the point at the narrows between the eastern expansion and the main body of the lake south-west, the mica schists, though broken by bands of pegmatite and coarse grained granite, form the principal rock. This band of mica schist is nearly half a mile wide; the strike on the north side is N. 80° E. and in the south side N. 65° E. with a uniform southerly dip of about 70° . Opposite this on the eastern shore this converging band of mica schists appears to have almost entirely died out, and is represented only by two or three narrow bands only a few feet wide, which bend sharply to the N. N. E. with a lower southerly dip, and are flanked by massive red coarse grained muscovite granite, containing numerous small garnets. The above distribution is graphically represented on the map by the two long narrow tongues of Cutchiching rocks.

South-western
part of Stur-
geon Lake.

The northern part of the peninsula forming the narrows at the north-east end of the main body of the lake, consists of pink muscovite granite, very coarse grained, pegmatitic in places, and often containing biotite as well as muscovite, and sometimes garnetiferous. The contact with the mica schists to the south is seen about half way down the western shore of the peninsula, south of this the mica schists are invaded by a few granitic bands. From here the contact must lie between the fine grained brownish-gray felspathic mica schist of the south-eastern shore of the lake and the pink, usually, distinctly foliated granite gneiss of the large off-lying islands. Neither the schists to the south nor the gneisses on the north contain bands of foreign rock, although some felspathic veins, probably segregated, occur in the former.

The contact line passes north of the islands, lying off the mouth of the deep bay of the south-eastern shore, as these islands are composed of mica schist, a narrow granitic band being seen on only one of them, and a single exposure of granitic rock is noted on the north shore of the bay.

Western shore
of Sturgeon
Lake.

The line of contact after passing under the waters of the lake, is again closely located on the west shore, as passing between adjacent exposures of the two varieties of rock. On the bay to the west, there are a few

exposures of felspathic mica schist, but on the north-western extremity two or three exposures of massive pink granite, taken in connection with the observed strikes, determine approximately the location of the line of contact. From here westward the line probably curves to the north-west to the contact of the Laurentian granite gneisses and Couthiching mica schists, located on the Quetico route from Namakan River to Kawagansikok Lake.

The limits of the area of Couthiching rocks have thus been traced, and the data from which they are laid down, given. The very numerous exposures of mica schists on all the lakes and river shores shown in this area, leave no doubt as to their general distribution and render highly improbable the existence of any considerable area of older or newer rocks, except in the unexplored portion north of Wolsely Lake and Namakan River.

General distribution of mica schist.

Character of the Rocks of the Couthiching Area.

The rocks in this area are singularly uniform in character. They vary in colour, from a light gray to a dark gray, sometimes with a tinge of brown, probably due to a bleaching of the biotite constituent, possibly in some instances due to the presence of iron-bearing minerals. They vary in texture from a medium-grained rock, in which the size of the mica scales is prominent, to a very fine-grained rock. Only occasionally in this area are they observed to be coarsely crystalline. They contain generally biotite, black, brown or bleached, or muscovite, with felspar (orthoclase) and quartz. The two latter are seldom or never absent, and sometimes these minerals are such important constituents, as to characterize the rock rather as a micaceous gneiss than a mica schist. These micaceous gneisses are always fine-grained, light gray, and finely and evenly laminated.

Hornblende is occasionally found as a more or less important constituent, and small garnets have been often observed.

In Namakan Lake, due north of the channel to Sand Point Lake, the schists are extremely coarse-grained, the mica, which appears to be a bleached biotite, or muscovite, occurring in large scales.

Coarse grained schist in Namakan Lake.

In some localities on the east shore of Sand Point Lake, particularly on the island at the mouth of the bay, leading to Nequaquon portage, the schist is coarse grained and black, from the abundance of hornblende contained in it in this locality characterizing it rather as a hornblende than a mica schist. The schists here dip away from the granite gneiss at unusually low angles, in one place as low as 17° .

Sand Point Lake.

Hornblendic schist.

Lac la Croix.

In Lac la Croix, on a small island north of Roland Island, is an exposure of rather coarse-grained hornblende schist, consisting almost entirely of hornblende in parallel crystals and needles ; this may be a small outlier of hornblende schist, but it does not appear to be an eruptive rock. In the channel, south of the eastern line of the Indian Reserve, at the mouth of the Maligne River, the schist is hornblendic and fine-grained, and there are also some light green chloritic schists one-half mile E. N. E. of the Dam Island portage ; these, in connection with the hornblende schist in Lac la Croix, above mentioned, may represent a band of basal Keewatin rocks, but if so, it is of insignificant development.

Possible pinched in-fold of Kee-watin rocks.

Maligne River.

Siliceous lenses.

Wink Lake.

Pegmatite.

Felspar rock.

On the Dam Island portage, up the river as far as Tanner's Lake, and at some localities on this lake, the mica schists, or gray evenly laminated gneisses, contain siliceous portions which resist weathering, and give to the weathered surface of the rock a knobby appearance and on the fresh fracture present oval or lenticular areas of lighter colour than the more micaceous and felspathic surrounding material.

The occurrence of these siliceous lenses is also noted on a small lake one and a-half miles north-east of Darkey Lake. The fine-grained grey felspathic mica schists of Wink Lake also present this feature.

On the stream forming the outlet of Darkey Lake, the mica schists are dark grey in colour and fine.grained. They dip to the N. N.E. at very low angles from 10° to 25° .

Small irregular areas of coarsely crystalline pegmatite, of which the mica is white in colour, occur. These patches are possibly segregations from the surrounding mica schist. The mica schists are also intersected by thin stringers of quartz and felspar, which are at times curiously contorted. Thin stringers or veins of felspar rock are noted on Sturgeon and Namakan Lakes, and are of very common occurrence in mica schists. The vein material seems to consist almost entirely of orthoclase. Most generally the veins cross, more or less obliquely, the strike of the schists. Sometimes two or more veins, having different directions, will join together or intersect each other. They rarely exceed three or four feet in width, but are very irregular in their outline. They are most probably segregations.

All the rest of the rocks in this area fall under the general description given above.

Isolated Bands and Areas of Mica Schist.

Narrow isolated bands of mica schist, which may represent the remnants of pinched in folds, and, therefore, synclinal troughs of Couthiching rocks, are noted in the granite areas more or less remote from the main Couthiching area, in the following localities :—

North of the extreme north bays of the main western portion of Sturgeon Lake, several bands of mica schist were observed. Their direction is parallel to the line of contact and their inclination to the north at rather high angles. One is seen to be a lenticular band only 30 or 40 feet long, the others are bands about a chain or so in width.

On the south-east arm of Sturgeon Lake, near the mouth of the stream draining the lakes east of it, is a band of uncertain width of soft, friable, brownish weathering mica schist. It strikes N.E. by E. and dips about 60° N.W. This is probably the eastern representative of the bands seen in the granites, south of the small lake, one mile and a half west south-west of this, which strike N. 75° E. and dip N. $< 70^{\circ}$.

On the fourth lake from this south-east arm, and draining into it, is a band two chains wide, apparently underlying the gneiss on the north-west shore.

On Chatterton Lake, on the south side of the large island opposite the portage into McDougall Lake, is a band apparently interbedded with the granitoid gneiss. Dip N. 10° W. $< 15^{\circ}$.

On the north-east shore, north-east of this island, is a band of brownish medium-grained mica schist, with a band of pegmatitic granite. Dip S. 75° E. $< 49^{\circ}$. Perhaps the same band as above.

On Kahnipiminanikok Lake, on the north side of the large island in Kahnipimin-anikok Lake, the north end, a narrow band of brownish-gray medium-grained mica schist occurs.

On the east side of the lake, at the mouth of the bay north-west of McKenzie Inlet, is a narrow band of black mica schist, dipping S. 80° E. $< 75^{\circ}$.

On McKenzie Inlet are exposures of dark gray hornblendic mica schist and brownish-gray felspathic mica schist in the localities indicated in the Couthiching area on the map. On the small lake between this inlet and the Kawawiagamak Inlet, a gray siliceous mica schist occupies a considerable area, which reappears as a dark gray compact fine-grained siliceous mica schist, skirting the south shore of the bay into which this lake drains. Opposite this, granite gneisses are exposed. On Kawawiagamak Inlet, mica schists are seen in considerable development; on the shallow bay on the north side near the mouth there is a fine-grained felspathic mica schist, which passes into an evenly laminated biotite gneiss. These exposures, with the observed strike, render it highly probable that the area exists as mapped. A subordinate southern extension of the south fork of this area is indicated by narrow bands of mica schist on the channel to Agnes Lake.

This area is probably a pinched infold of Cutchiching rocks invaded by an apophysis of granite. No synclinal structure is, however, shown by the dips.

South-east part of Kahnipiminanikok Lake.

At the narrows, near the south-east end of the lake, and on the bay north of McEwen Lake, are exposures of fine-grained hornblendic mica schists, which by their localities and the strike of the rocks indicate the presence of a crescent-shaped area, of probably Cutchiching rocks, as shown on the map.

Broad band of Cutchiching rocks.

On the south-east shore of the small lake, south-east of Kahnipiminanikok Lake, and on the stream flowing into it from the south-east, is a well-defined band of fine-grained felspathic mica schist striking E. N. E. and dipping north-westerly from 60° to 70° . This band is here about three-eighths of a mile wide, and is doubtless a north-eastern extension of the band, well defined in McEwen Lake, of very fine-grained evenly laminated gray biotite gneiss, merging into coarser-grained, darker and more fissile felspathic mica schists. Here the band curves a little more to the south and has a somewhat lower north-westerly declination.

McEwen Lake.

The reasons for mapping the eastern extension of this band in continuation with the Keewatin rocks, will be given later.

Slate Lake.

On the south-west end of Slate Lake, the exposures of a mica schist, in which the mica is smoky-white in colour, apparently muscovite, but possibly a bleached biotite, indicate the existence of an area of Cutchiching rocks sufficiently extensive to be shown on the map. An exposure of this rock at the bottom of the bay of Saganagons Lake, north-east, indicates a north-eastern extension of the band at least that far. Along the north-east shore of this bay the granites contain narrow bands of mica schist, which are, however, subordinate in quantity. The westward extension of this area is not determined, but is judged to be short on account of the rapid convergence in the direction of the strikes; on the north side of Slate Lake (S. 70° W.) and on the south side (N. 70° W.)

The lamination on the north side is vertical, and that on the south side dips to the south at a very high angle.

Agnes Lake band of mica schist.

On the north shore of Agnes Lake, between its two outlets, is a series of mica schists interbanded with the foliated granites in such abundance as to become a prominent constituent of the whole rock mass. The strikes vary from N. 50° E. on the east to N. 20° E. on the west. The manner of their occurrence is very suggestive of sedimentary interbedding. To the east the dip is S.W. $< 16^{\circ}$ rapidly increasing in declination to 45° . On the most prominent point of this shore, the mica schists have a low easterly dip of 5° , and west of this

Apparent sedimentary interbedding.

the dip is again reversed, dipping westerly at an angle of 35°. This low dips would indicate an eastern synclinal and western anticlinal fold, but Areas of no indication of a syncline still further west is observed. The island folding south-west of the western outlet is composed of foliated granite, holding brecciated angular fragments of mica schist.

On the east side of Basswood Lake, east of the large island in the Basswood Lake. northern part, some small bands of mica schist occur, and further north-east is some fissile light gray micaceous gneiss, closely allied to the Coutchiching gneissic rocks.

On the point at the west end of Yum-Yum Lake, a local narrow Yum-Yum Lake. band of siliceous hornblendic mica schist occurs.

On this lake, as well as on McNiece Lake, and on the east side of McNiece Lake. Shade Lake, bands of this hornblendic micaceous schist are associated with the red foliated chloritic granites.

Thickness of Coutchiching series.

Any attempt to arrive at the probable thickness of the Coutchiching Difficulties of series is confronted with many difficulties, and the result must be determination accepted with hesitation, as being very uncertain, owing to the many possibilities involved in the structure, which cannot all be duly regarded.

Dr. Lawson's estimate* of the thickness of the series in the Rainy Lawson's estimate. Lake district is based on very evident and significant facts, and it will be interesting to see how far the facts of this field, similarly interpreted, corroborate his estimate.

Dr. Lawson considers the whole volume of mica schists, south of the Keewatin area, to represent a threefold repetition of the series folded over a northern anticlinal and under a southern synclinal axis. The portion between the Keewatin schists and the anticline, he estimates to have a thickness of 4·50 miles. The portion between the axes he estimates at 4·588 miles, and the southern third at 5·44 miles thick, which, allowing for uncertainties of data, would indicate a much greater thickness for the series to the south than to the north.

The northern anticlinal axis, described as striking the shore of Rainy Granite area Lake between Rat River and Vague Point, crosses the Pipestone on line of River about one mile and a quarter from its mouth, where diverging dips are seen; thence its eastern extension marks the centre line of an ovoid area of Laurentian rocks, the southern edge of which is exposed on the north shore of Sturgeon Lake; so that in the Hunters Island district only the southern synclinal basin is seen in its extension eastward from Rainy Lake.

*Geol. Survey of Canada, Annual Report, vol. III., 1887-88, p. 100 F.

Eastern extension of Rainy Lake syncline.

The axis of this basin, along which the dips converge, can be traced from Kettle Falls, with a course east by south, north of Namakan Lake, south of Captain Tom Lake, touching the northern bend of Namakan River, whence it sweeps to the south of Wolseley Lake; from here it curves more to the east, encroaching, probably, on the north-east part of Indian Reserve "D," skirting to the north of Maligne River to cross it at the dam at the outlet of Sturgeon Lake, and passes between Sturgeon and Hoffmann lakes.

Thickness north of Sand Point Lake.

From the contact of the Coutchiching and Laurentian on Sand Point Lake, to the axis above described, the distance is about $5\frac{1}{2}$ miles. The angle of dip varies between 25° and 70° , and for the first three-quarters of a mile north of the Sand Point Lake granite, may be taken to average 60° ; for the next three-quarters of a mile, 30° ; for the next mile and a half, 60° ; for the next mile, 40° ; for the next mile, 65° ; and for the last half-mile, 80° . Making the corrections for these angles of declination, these measurements would give a thickness of 4.367 miles, considerably less than that found for this portion of the trough further west; but here the series might be expected to be thinner, and the calculation is based on a position of the synclinal axis determined from data obtained since Dr. Lawson's report was written.

Thickness of northern half of basin

For a calculation of the northern half of this fold, there are no data sufficiently accurate to give satisfactory results. The distance between the synclinal and anticlinal axes on a line of section continuous with the above would be probably between five and a half and six miles, and if we assume the dips to be the same as for this part of the fold on Rainy Lake, viz., about 75° , the thickness would appear to be about 5,000 feet greater than that deduced by Dr. Lawson there. No reliance can, however, be placed on this calculation.

Thickness east of Thompson Lake.

From where the axis of convergence can be located as striking the Namakan River at the mouth of the Quetico River (the northern bend), south to the granites, can hardly be less than seven miles. The rocks have, however, a more uniform and a lower dip, averaging for the northern four miles about 60° , and for the southern three miles, 45° , which would give a thickness of 5.548 miles, greater than that calculated by Dr. Lawson. The series here, however, may have been thickened by the intrusion of the granites of Thompson Lake.

Thickness of northern fold.

North of the synclinal axis the contact with the mica schists and the granite area, seen in part on this sheet on the north side of Sturgeon Lake, cannot be accurately defined, owing to the very broad zone of alternate bands of granite and schist, but the granites first appear decidedly to predominate along a line rudely parallel with this axis and distant from it about $5\frac{1}{2}$ miles. For a mile and a half north

of the axis the schists dip to the south, and north of this they dip constantly to the north under the northern granites. This indicates another anticlinal axis, probably due to an intermediate local disturbance, for such an axis is not seen on Rainy Lake. Ignoring this and assuming the average dip for the whole five miles and a half to be 65° , a thickness of 4.985 miles would be indicated.

The axis of convergence of dip can be only approximately laid down north of Lac la Croix, but it probably lies about four miles and a half north of the contact on Roland Island. For the first three miles north of the contact the dips are low, ranging from 30° to 45° , and averaging about 40° . The dips for the next mile would have an average of about 65° , and for the last half mile about 80° , giving a total thickness of 3.327 miles, which indicates a thinning of the series towards the east.

Neither the axis north of Tanner's Lake, nor the contact north of Wicksteed Lake, can be very accurately placed, but the distance between them would be about four miles. From the dips observed on the stream draining Darkey Lake, they would appear to be very low, averaging not over 25° for the southern mile and a half of this distance. The average for the next two miles, as revealed on Tanner's Lake, and on the portage south of it, would appear to be about 50° , and for the last half mile we may assume an average of 80° , giving a total thickness of 2.658 miles, indicating a still greater attenuation of the series.

Still further east the series seems to have been split and wedged apart by the syenites of Pooh-Bah Lake. South of the syenites, the most reliable measurements would give a width of two miles to the schists, which have here an average dip of 45° , or a thickness of 1.389 miles, underlying the syenites. From the northern edge of the syenites to the axis of convergence of dip at the Maligne dam, the distance is 1.6 miles, the schists have an average dip of about 60° , which would give them a thickness of 1.386 miles, overlying the syenites. The total thickness would thus be 2.775 miles, somewhat greater than the last, but it is uncertain what effect the intrusion of the syenites would have upon the thickness of the series, at the present level of denudation, by the introduction of intermediate folds.

The only place where satisfactory evidence of the thickness of the northern upward fold of the series is afforded, is on the west shore of Sturgeon Lake, where the horizontal distance across the fold is under two miles and the declination averages 75° , giving a thickness of 1.932 miles. A rapid thinning of the series would be expected so near the eastern end of the trough.

Allowing for local variations in the thickness of the series, and for inaccuracy and incompleteness of data, it is thus seen that in the Hunters Island region the enormous thickness revealed in Rainy Lake is maintained, and the calculations based on the same interpretation of the structure, give practically the same results.

Reasons for regarding the thickness as too great.

Metamorphism.

Unusual development.

Period of folding of Couthiching and Keewatin the same.

True thickness more nearly determined in intermediate bands.

There are, however, weighty reasons for doubting the results of these calculations. In the report on the Rainy Lake region,* it is pointed out that the intervention of the mica schists between the granites and the rocks of the Keewatin series, has preserved the latter from the intense metamorphism which they exhibit when in direct contact with the former. It is, therefore, surprising to find that these mica schists, which would here seem to have been deposited in such enormous thickness, should exhibit comparatively little difference in degree of metamorphism, between its upper and lower members. Again, it is surprising to find here a development of a singularly uniform series, unparalleled by any other series of upper Archæan rocks, particularly in view of the fact that in no other part of the whole field between the Lake of the Woods and Lake Superior, is anything more than a comparatively subordinate development of mica schists observed.

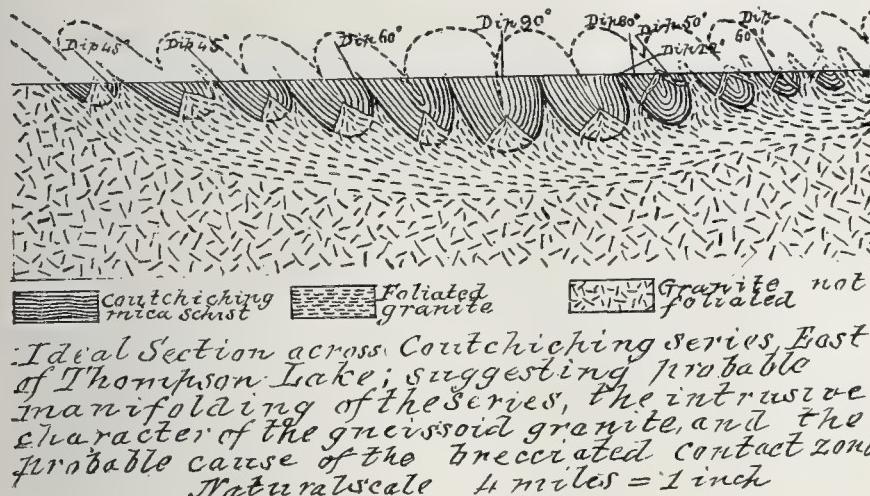
The contact between the Laurentian and the Couthiching rocks, and between the former and the Keewatin presents the same characteristics; and no unconformity of structure between the two upper series has ever been observed. It is therefore highly probable that the two series were folded at the same time, and it is therefore most likely that the true original thickness of the Couthiching rocks would be more nearly arrived at from measurements taken where these rocks are found in position between the Laurentian and Keewatin rocks, than in the main areas where the apparent thickness may have been manifolded by intense and minute plications. In the area comprised within this sheet, no such occurrence of the mica schists is seen, but one such instance is afforded on Rainy Lake, where the band of schists south of Pither's point, lying between the Keewatin belt on the south and the Laurentian area on the north, has been computed as 8,000 or 9,000 feet thick†. As pointed out in connection with this statement, the comparative thinness may be due to partial absorption of the mica schists into the magma from which the granites recrystallized, but this supposition is contradicted by the fact that the southern half of the southern synclinal basin, which would be subject to the same influence, is thicker (on the double synclinal interpretation of the structure) than any other part of the series.

*Geol. Survey of Canada, An. Rept., vol. III., 1887-88, Part I., p. 38 F.

† Geol. Survey of Canada, An. Rept. vol. III., 1887-88, Part I., p. 104 F.

A minute study of the section east of Thompson Lake reveals the following facts:—The schists at the contact on Roland Island have a northerly inclination of 45° , and this is the prevailing dip for three miles north; 60° being the average northerly dip for the remaining four miles to the axis of converging dips where the rocks are in vertical position. For one mile north of this axis the rocks have a prevailing dip to the south of 80° . One mile and a half north of the axis a dip of 22° S. was observed; at two miles north the declination is 80° to the north, lowering to 50° half a mile still further north; for the remaining three miles, to the line of predominance of the granites, the dip is uniformly to the north at angles differing little from, and averaging 55° . The section below represents what, in the writer's opinion, is the most probable structure of the rocks along this line.

Fig 3



The alternating bands of foliated granite and mica schists, in the contact zone, may thus be accounted for not only by intrusive dikes of the granite, but by intrusions between the folds, and the shattering of the crumpled schists particularly at sharp synclinal turns and the intrusion of granites into these fissures. A comparatively thin series, thus manifolded would have a comparative uniformity of metamorphism throughout.

The low dips often observed in central portions of the basin might thus indicate proximity to the crest of an original anticline or to the trough of a syncline.

This interpretation of the structure nullifies all data from which a calculation of the original thickness can be made, and affords only a

reason for believing that the Coutchiching series is much thinner than it has previously been considered to be.

KEEWATIN SERIES.

Limits of area and conditions of contact with lower rocks.

Work done in
Keewatin
area.

It is unfortunate that, for reasons already given, I cannot describe these rocks with the thoroughness and minuteness that their scientific and economic importance deserves. A reference to the record of work, previously given, will show how little of the work in the area occupied by Keewatin rocks was performed by me. In 1888, I spent three days on Saganagons Lake, during which a hasty visit was paid to the most northerly of the mining locations, south-west of the lake. In July, 1888, I passed hurriedly from Basswood Lake through Birch, Carp, Emerald, Big Rock and Jasper lakes to Saganagons Lake, taking cursory notes on the way without any expectation of requiring them for future use. I surveyed the islands in Saganagons Lake. Mr. Russell had made an excellent traverse of the shores of the lake, a plat of which he kindly gave me, so that less attention was paid to the rocks of the shore than they would otherwise have received, but the notes and specimens collected at this time, form the only systematic geological work in this area that is at hand.

Contact in
Basswood
Lake.

Glacier Lake.

The contact of the Laurentian and Keewatin rocks, shown in the north-east corner of the extreme eastern expansion of Basswood Lake, has been determined by Dr. Lawson. The contact of the granites of Meadows and Louisa lakes, with the Keewatin rocks of That Man's and This Man's lakes, must lie somewhere between them and in a line generally parallel to these chains of lakes, as the foliation of the rocks in both chains is coincident with the general trend of the shore lines. The next point north-east where Keewatin rocks were seen in contact with Laurentian, was on Glacier Lake, where a band of fine-grained black siliceous hornblende schist was found, the width of which could not be determined; it is exposed along the eastern shore for about a quarter of a mile, having a strike in the central part of this distance of N. 80° E. with a southerly dip of 45° , a single exposure opposite this on the west side of the lake has a north and south direction of strike. It is again exposed at the southern extremity of the lake, at the portage to Cross Lake; here the direction of structural planes is also north, with a low west-erly dip of about 40° , the reversal of the dips and their low declination together with the sharp change in the strike indicate considerable disturbance. The contact with the distinctly laminated pink biotite gneiss of this lake was everywhere concealed by drift, the shores afford-

ing only isolated exposures. The gneiss in the neighbourhood has a strike of N. 25° E. which would indicate probably the general direction of this band. The band is probably of insignificant width, from the fact that no certain continuance of it is seen to the north-east.

South-west of this, on the portage between the two small lakes north-east of Louisa Lake, a band of precisely similar rocks to these, but so narrow in development as to be inappreciable on the scale of the map, is associated with the light gray distinctly foliated biotite gneiss, which here strikes N. 35° E., with a south-easterly dip of 80° . On the northernmost island, lying near the north-west shore of this lake, is a narrow band of similar hornblende schist, interbanded with a fine-grained red granite, in which the bi-silicate is changed to chlorite; here the hornblende schist strikes N. 45° E., and has a low north-westerly declination of only 10° . No occurrence of this band is seen between these two localities, but the rock exposures are comparatively infrequent, and the band is probably continuous. On the portage between Louisa and Agnes Lakes is another exposure of hornblende schists dipping S. 45° E., angle 80° . No intermediate occurrence of this band is seen, but where it would be expected the rocks on the shore of the lake are concealed by sand. These three exposures of hornblende schist are therefore nearly linear with each other in their localities and in the direction of their structural planes, and it would seem that they probably represent fragmentary portions of a pinched infold of Keewatin rocks, parallel to the main trough to the south-east. I have not mapped the rocks seen in Glacier Lake, although very similar in character, as continuous with this band, as the direction of the former in its most southerly occurrence seemed to suggest that it was rather an apophysis of the main mass than a greatly thickened development of the Louisa Lake band.

The next place where the contact is seen is in Slate Lake, lying to the west of the south-west end of Saganagons Lake, on the southern bay of which massive quartzose hornblende schists are exposed. On the peninsula between the south and west bays is an important exposure of red, rather coarse-grained granite gneiss, in which the bi-silicate would seem to have been hornblende, now changed to chlorite. The actual contact, though not well exposed, presents the usual zone of interbanded granite and schist, here, however, narrow, with but few alternating bands. From the direction of the strike of the rocks here, together with the strikes observed by Dr. Lawson on The Other Man's Lake, there can be little doubt that the line of junction to the south-west is approximately as indicated on the map. The schists on the north shore of Slate Lake, north-west of the granites

Parallel small
band of horn-
blende schist.
Louisa Lake.

Band pro-
bably con-
tinuous.

Contact in
Slate Lake.

above described, are mica schists, so characteristically Couthiching as to leave little doubt as to their correlation with that series.

Contact in
Saganagons
Lake.

The bottom of the bay of Saganagons Lake, north-east of this, is occupied by granitoid gneiss, distinctly foliated and holding bands and lenticular inclusions of hornblende schist. On the long narrow point forming the south-western shore of this bay, the bands of hornblende schist or schistose trap become so frequent as to predominate over the foliated granites, and the contact is, therefore, placed north-west of this point. The islands at, and to the north-east of, the mouth of this bay present the same features of interbanded and foliated granites and black schistose rocks, indicative of the contact zone. The rocks here strike N. 35° E., and dip S.E., angle 80° . The large triangular island, three-quarters of a mile north-east of the above mentioned point is composed almost exclusively of hornblende schist.

The line of junction passes through the islands, and crosses the narrow neck of land, cutting off the point north of the trail which forms a winter route to Saganagons Lake. This point and the small islands to the west of it, are composed of hornblende schists, while the shore of the shallow bay to the west presents numerous exposures of deep pink obscurely foliated granitoid gneiss. The bay north and east of this point, presents no exposures, but the extreme point, one-half mile to the north-east, offers an exposure of hornblende schist.

Chloritic
schists.

Deadman's
Point.

A single exposure of granite, probably interbanded, is seen a few chains to the north-west. Here the rocks become chloritic in composition, the rocks on the point of the shore to the east being soft, fissile, dull green, quartzose chlorite schists. The contact is again determined in the bay north of Deadman's Portage, which crosses the narrow part of the long tongue of land which runs north-east to the eastern boundary of Rainy River district. This tongue is called Deadman's Point, doubtless from the fact that it has, for years, been a favourite cemetery of the Indians, several of their curious elevated coffins still remaining there. The portage crosses just east of the last point described. The tongue of land is occupied by hornblendic and chloritic schists. The south-western shore of the north-western part of the lake affords many exposures of reddish, coarse-grained biotite granite gneiss, having a strike of N. 50° E. The contact lies in a grassy bay in the extreme south corner. The junction can be traced as lying between adjacent exposures of hornblende schist and foliated pink granite, on the off-lying islands skirting the south-east shore of this part of the lake ; the usual strike being about N. 50° E., with local variations to N. 70° E., the rocks being nearly in a vertical position. The contact on the north shore of the lake, west of the narrow channel

to the eastern part, cannot be very closely located, owing to the stony character of the shores of the bay, but it must lie between the reddish biotite granite, indistinctly foliated, exposed on the point between the two deep bays to the north, and the chloritic hornblende schists revealed on both sides of the narrow channel between the north shore and the long narrow island to the south-west. The rocks on both sides of the contact line have a common direction of foliation of N. 70 E. The granites do not reveal the dip clearly, but the schists are in vertical attitude. The line of junction from here would seem to sweep from the north-east to the north, then to the north-west to form the south-western edge of the band of hornblende schists, indicated by the occurrence and strike of these rocks exposed on the shores of the lake west of Ross Lake, crossed by the boundary line between the districts of Rainy River and Thunder Bay. The rocks strike in a west-north-westerly direction from this lake, and in the east end of it they strike a little north of east, and due east near the centre of it; while several exposures in the west end of the lake show a uniform strike of W.N.W. The dip is uniformly to the south and south-west, at an angle of 45°. The width of this band is uncertain, but a westerly projection of the strikes noted would indicate a width of not less than three-quarters of a mile just west of the lakes, although it probably becomes attenuated in its westerly extension. This westward extension is a matter of conjecture; but, for the following reasons, I have mapped it as in continuance with the mica schist band of McEwen Lake, as being probably representative of the facts.

This band is seen to strike west-north-west. The McEwen Lake band of mica schist, characteristically Couthiching, is seen in its most easterly exposures, on the shores of the chain of lakes and connecting streams forming the outlet of Saganagons Lake, to strike east north-east. The projection of these two directions would intersect. For many reasons, which need not be detailed here, it may be assumed that the periods of folding of the Keewatin and Couthiching rocks were identical. These bands represent synclinal folds of the Laurentian rocks, and whether the latter were in a viscid or in a hard condition at this period, it is simpler and more rational to conceive of a single curved trough than of two intersecting ones. Couthiching and Keewatin rocks are frequently found occupying the same trough, the Couthiching being always the inferior series, and generally seen to flank the Keewatin schists on both edges of the trough, while Couthiching rocks may be found exclusively at one end of the trough and Keewatin rocks exclusively at the other end. The mapping, therefore, represents on a small scale conditions found to obtain elsewhere on a larger scale.

Lake west of
Ross Lake.

Reasons for
mapping
McEwen
Lake band in
continuation
with branch
of Keewatin
rocks of Sag-
anagons
Lake.

While this represents, therefore, the most probable distribution, it is by no means certain that these bands do not terminate before reaching the point of intersection or of union, but bands of Cutchiching and Keewatin rocks, in granites, are usually found to extend for such great distances, in proportion to their width, that this supposition is unlikely.

Rocks on
Ross Lake.

On the north side of the channel into Ross Lake, there are very few exposures, but such as there are indicate a continuous band of hornblende schists on the north side, striking east and dipping at a low angle to the south. On the south shore of the channel, near where it expands into Ross Lake, are some exposures which indicate the existence of a band of granitic rocks. The hornblende schists of the north side of the channel are again seen on the small island lying close to the south shore of Ross Lake, where they strike a little south of east and have a low southerly dip of 45° from the strike here, and on the west side of Beaver Lake it is probable that the band is continuous with the main mass to the south, and locally separated from it by a lenticular band of granite exposed on the south shore of Ross Lake. These exposures may indicate only small local intruded bands of granite, but in the absence of intermediate exposures of hornblende schists, it is mapped as representing a considerable band. This affords a graphic representation of a very frequent occurrence, though usually on a much smaller scale.

Intercalated
granitic band.

Beaver Lake.

The north shore of Ross Lake and both shores of the channel to Beaver Lake afford a few isolated exposures of granitic rocks. There are few exposures in Beaver Lake, but such as there are, are of granite on the north side, and of dark green hornblende schist on the south side. On the south side the strike of the schists curves round from south of east, near the west end, to N. 75° E., at a point near the middle of the lake, the dip also becomes steeper, changing from 45° S. on Ross Lake to 52° S. at the west end of Beaver Lake and to 80° S. at the point near the middle of the lake. At the narrows, three-quarters of a mile east of Beaver Lake, the granite is fine-grained and red in colour, with a little biotite; it is cut by intersecting cleavage and jointing planes, one set of which, striking N. 65° E., would seem to represent the true structural planes of the rock. There are so few exposures on this route that the line of junction cannot be laid down with great precision, or described as to its character, but there is little doubt that it is defined on the map with as much accuracy as the scale will permit.

South-eastern
boundary of
Keewatin
area.

As to the south-eastern boundary of the Keewatin belt, it was nowhere traced or examined by myself, but it has been closely defined by Dr. Lawson and laid down by him on the map.

The question of the age of the rocks of Saganaga Lake, in contact with the Keewatin, will be discussed later.

The line of junction is seen, on the Canadian side of the international boundary, only in and on the west and north shores of Cache Cache Bay. Bay of Saganaga Lake, and along the north-west shore of the main lake in one locality. It skirts along this shore, the mainland being occupied, for the most part, by Keewatin rocks, while the off-lying islands are composed of granites.

An interesting series of specimens, collected by Dr. Lawson from Conglomerates. Cache Bay, reveal the presence of a felsitic conglomerate in contact with a coarse-grained hornblende granite.

The conglomerate holds well water-worn pebbles of various sizes, usually as large as a hen's egg; these pebbles are of white and bluish quartz and coarse-grained hornblende granite; the matrix is a medium grained aggregation of quartz and felspar, with a little decomposed bi-silicate. The matrix has a granitic aspect and appears to be itself a finer conglomerate, made up of many partly-rounded grains of felspar and quartz cemented together. Beds of dolomite are associated with this conglomerate. Not having myself examined the localities where this conglomerate is exposed, I can say nothing of its relations in the field or of its stratigraphical significance.

On the north side of Cache Bay the contact between the hornblende schist and the granite gneiss is well exposed and is very characteristic of the contact between the Laurentian and upper Archæan or Huronian rocks of this district. Three photographs showing the nature of this contact at different localities were taken by Dr. Lawson, and are here reproduced. Plate I. represents what I shall so often have occasion to describe as the interbanded structure of the gneiss and schists. These lenticular bands of hornblende schist (dark coloured portions in the plate), included in the hornblende granite gneiss (light coloured portion), are not always so abruptly terminated, and often maintain a comparative uniformity for hundreds of yards. The appearance is frequently suggestive of an interbedding of the two series at the contact, and but for the brevity of these beds, and their sometimes rounded ends, such as shown in this plate, one would be apt to regard them as true interbedded depositions.

In plate II. is seen a common feature along the junction between the granites and the Couthiching and Keewatin rocks, viz., the inclusion in the granites of scattered angular fragments of schistose rocks. These angular fragments usually have the appearance of having been broken and torn apart by longitudinal stretching. The longer axes of the fragments are nearly always parallel with the contact planes, and

Character of contact in Cache Bay.

Lenticular bands of hornblende schist.

Angular fragments of schist in granite.

sometimes would seem to have been moved but little from their original position as parts of the massive schistose series. Again, these scattered sharply angular fragments are often seen many yards from the contact, and isolated occurrences of them embedded in the granite have been noted a mile or more from any important development of similar rocks.

Granite dike. Plate III. represents a bifurcated dike of hornblende granite (the lighter portion) striking from the main mass of these rocks into the hornblende schists across their planes of stratification.

Phenomena figured characteristic. These plates afford very strong evidence of the intrusive character of these hornblende granites, and the phenomena here shown are of such frequent occurrence all along the line of contact of the Laurentian and the upper Archæan rocks, as to characterize the general nature of the junction and to strongly support the supposition that the Laurentian rocks of this region are as a whole irruptive in their relations to the overlying series.

Character of some of the rocks of the Keewatin belt.

Rocks in Birch Lake. On Birch Lake the rocks exposed are coarsely crystalline hornblendic rocks, not very schistose. With these are associated very fine-grained fissile dark gray slates, apparently little altered clay slates. On Carp Portage, at the west end, these slates strike N. 58° E., and have a south-easterly declination of 84°. These schists or slates are almost continuously exposed on the south shore of Carp Lake, becoming more greenish in colour and softer, but less finely fissile, as we cross the series to the south, where they are exposed on the bare hills as soft chloritic schists.

Between Carp and Emerald Lakes, is a small lake surrounded by bold hills of massive "greenstone." These rocks are dull dark greenish-gray in colour, very hard, and they have as a rule very little schistose structure.

Emerald Lake. The shores of Emerald Lake are very steep, presenting high, rugged cliffs of this same massive greenstone. At the east end of the lake, on the north shore, the rock is black in colour, compact and fine-grained, and appears to contain a small percentage of iron.

Big Rock Lake. The rocks exposed in Big Rock Lake are fine grained, light greenish-gray altered trap or "greenstone." It is sometimes cut by jointing planes, but no true schistose structure is discernible. The rock is often deeply stained with iron rust. This appearance of iron oxide staining is often closely simulated by an orange coloured lichen, which adheres very closely to the surface of the rocks, and at a distance is quite indistinguishable from the orange-brown stains caused by the deposition

Iron staining

of scales of iron oxide left on the surface by percolating waters. Prof. Macoun states that this lichen is the species *Placodium elegans*.

Cypress Lake seems to lie entirely in this greenstone horizon, these rocks being exposed almost continuously along the shores, which are high, rugged, perpendicular escarpments, rising abruptly from the water's edge for over one hundred feet. These scarped faces are very much stained with iron oxide.

On the portage between Cypress and Jasper lakes black crystalline hornblende schists are exposed, striking N. 56° E., and in vertical attitude.

On Jasper Lake, the massive greenstones appear associated with schistose traps and black crystalline hornblende schists. The structural planes of the schistose rocks strike in a direction between N. 55° E. and N. 60° E., and are, for the most part, vertical. Near the point at the south end of Jasper Lake, the rock is a fine-grained dark greenish-gray altered trap, which shows evidences of crushing and shearing. On a small island in the centre of this lake, is a fine grained dark gray siliceous rock, probably a variety of eruptive rock. In the bottom of the bay to the north-east, the rock is dark greenish-gray, compact and fine-grained, and would appear, macroscopically, to be an altered diabase. The shores of this lake are less rugged and precipitous.

On the portage going north out of Jasper Lake, massive greenish-gray hard greenstones are exposed. Associated with them, is here a band of ribanded jasper and haematite. The alternating bands of purplish haematite and cherry-red jasper have a comparatively uniform width of somewhat less than an inch; they are contorted and twisted in the most curious way, and present a beautiful appearance on the surface. This band is about forty or fifty feet wide, flanked on both sides by the greenstones above described.

There are, no doubt, many other occurrences of this banded jasper and haematite associated with the greenstones to the south-west, the localities of which would be indicated by the mining locations shown along the route, the rocks of which I have briefly described.

This occurrence of jasper and iron ore associated with massive greenstones in this Keewatin belt, has great importance and significance, and is most encouraging to those interested in the iron industry of western Ontario. This belt of Keewatin rocks is shown on the "Geological Map of Iron Regions of Minnesota,"* as being in direct continuance with the belt of rocks, which the Messrs. Winchell also

Importance of occurrence of jasper and haematite.

Same belt as at Tower and Ely.

* Published in 1890 by N. H. & H. V. Winchell, State Geologists of Minnesota.

call Keewatin, in which are located the exceptionally rich mines of the neighbourhood of Tower and Ely.

Similar association of rocks at Tower and Ely.

There the ore bodies are found associated with greenstones and greenstone schists, and capped by formations of banded jasper and haematite, the removal of the silica and its replacement by iron oxide under favourable conditions giving rise to the solid ore bodies below. There is every reason to believe that beneath the jasper and ore capping in the region south-west of Saganagons Lake, the same agencies have produced the same result of concentrating the ores in workable bodies, that have operated to produce this result in the same belt less than sixty miles to the west-south-west. It is to be regretted that these Canadian localities have not been thoroughly tested, not only from an economic stand-point, but from the increased knowledge that systematic testing would give of the relation of the ore to the inclosing rocks.

On the lake between Jasper Lake and the long south-west arm of Saganagons Lake, are light greenish-gray altered traps or greenstones, in some places quite schistose on the surface and fissile under the hammer, and in others quite massive.

On the portage between this lake and Saganagons Lake hornblende schist is exposed. It strikes N. 40° E. and dips at a very high angle to the north-west. There is seen also on this portage a very slightly schistose rock, probably related to the greenstones, which holds fragments of jasper.

Passing up the westerly arm of Saganagons Lake the rocks exposed are massive, hard greenstones on both sides. These rocks continue up the north shore past the portage into Slate Lake, above mentioned.

The rocks near the line of contact with the Laurentian, along the north-west shore, have been described as far as Deadman's Portage.

On the south shore from the trail, which is part of the winter route shown to Saganagons Lake, east to the mouth of the first bay running to the south, the rocks are light greenish-gray, fissile schists, apparently quartzose, chlorite schists, but possibly derivatives, by crushing and shearing, from the massive greenstones. These rocks on the fresh cleavage surface have a somewhat greasy feel. In the bay to the south a massive hard black eruptive rock is seen, which is probably of later age; whether it is diabase or diorite cannot be macroscopically determined with certainty owing to its fine texture. At the mouth of this bay on the eastern side, massive, hard greenstones are exposed, while on the small islands and on the large one opposite, the fissile, light greenish-gray rocks, above described, are seen.

South-west area of Saganagons Lake. Greenstones.

Saganagons Lake rocks.

Chlorite schists.

The large island to the east presents few exposures, but there is one of greenstone which is also exposed almost continuously on the main shore opposite.

On the small island between the east end of this island and the main south shore, the rock is schistose and weathers a dull light greenish-gray. While it closely resembles the chloritic schists to the west it does not break with the same smooth cleavage nor has the cleavage surface the same unctuous feel. It probably differs from it, however, only in degree of alteration.

The rocks adhere in their strike very closely to the general trend of the shore line, striking N. 85° E., and dipping south $< 80^{\circ}$. On the shore to the south a local flexure in the strike is seen in conformity with the trend of the south shore of the little bay which strikes of S. 70° E.

On the east end of the large island no exposures are seen, but on the north shore a continuation of the schistose chloritic rocks exposed on the large island to the west is seen ; the strike is here N. 85° E., dip S., angle 80° . On the shore of Deadman's Point, opposite the west end of this island, a rock is exposed which is very much sheared and crushed, it is rather coarse grained and contains felspar, quartz and chlorite, some of the felspar crystals appear to be porphyritic as well as some of the grains of quartz, and it would thus seem to be allied to the quartz porphyries ; lying so near the granites, however, it may be genetically associated with them, and have received its present structure from accidental causes. To the west no occurrence of it is seen. An exposure of it is seen on a low hill a few chains to the north, but it does not occur along the north shore of Deadman's Point.

It is exposed for a few chains along the south shore, to the east, where its southern contact with the green schists can be closely defined, although the actual line of junction is concealed under the sand. These exposures, therefore, probably represent a narrow lenticular subordinate band. It is in strict conformity with the associated green schists, which strike of N. 60° E., and are vertical, or dip at a very high angle to the south.

East of this at the southern extremity of Deadman's Point, the green schists are seen ; here they are not very fissile.

On the island nearly half a mile east north-east of this, the rock, while slightly schistose, assumes more the appearance of a greenstone. North-east of this the rock decidedly belongs to the greenstone series. The chain of small islands between here and the south-west point of the large island east of the extremity of Deadman's Point, are composed of schistose rocks, somewhat darker in colour and partaking more

Rocks of
Saganagons
Lake.

of the character of hornblendic schists ; these rocks are also exposed on the northern part of this island. On the south-west point of it, however, is an abrupt high rounded *roche moutonnée*, of massive rock, somewhat darker in colour than, but no doubt related to, the greenstones. Along the south shore of this island there are few exposures ; but near the middle and the east end, the greenstones are again seen, here containing irregular and crooked stringers of quartz. The small island lying off the main south shore opposite, also exhibits the same rock, containing similar stringers of white quartz. These quartz veins are comparatively a common feature, not only in the greenstones but in the more fissile chloritic schists.

None were seen of any considerable width, they are not more than two or three inches, and seem to be veins of infiltration, which, as a rule, cut across the structural planes of the rock.

Magnetite in
greenstones.

The greenstones of Saganagons Lake do not generally affect the compass strongly ; but in this neighbourhood they contain sufficient magnetite to cause the needle to diverge considerably from the magnetic meridian.

On the main shore, opposite the east end of the large island last referred to, the rock is schistose but not fissile, it is light greenish-gray in colour and strikes N. 75° E. with a vertical dip. East of this the strike curves to the east in conformity with the shore and the rock becomes very fissile. Then for a mile along the south shore of this eastern part of the lake, there is no exposure. From here these light greenish-gray fissile schists are exposed all along the south shore to the eastern end of the lake. The strike changes from east to N. 75° E. in strict conformity with the general sweep of the shore line. The dips are south at angles never less than 75° and often vertical.

Saganagons
Lake, east
end.

Crossing the strike of the rocks along the eastern shore at the end of the lake, we find in adjacent exposures the rocks becoming darker in colour, coarser in texture and revealing distinct crystals of hornblende ; the rock is quite schistose, although harder and more compact than the chlorite schists.

Hornblende
schist.

This hornblende schist is seen in the north-east corner of the lake, and all along the north shore of the large island south-west, and on the small islands between this and the north shore of the lake.

Hornblendic schists merging into ordinary black medium grained hornblendic schists are seen at several points along the north shore westward to the north-westward contact of the granites, and in the channel forming the outlet of Cross and Beaver Lakes. East of this channel the shore line adheres closely to the strike of the rocks.

There is considerable evidence in support of the belief that the light Chloritic greenish-gray chlorite schists described as representing a large proportion of the rocks exposed about Saganagons Lake, and seeming to differ from the greenstones in external character, only in the varying degree of their schistosity, are derived by crushing, shearing and metasomatic change from these greenstones.

Their macroscopic appearance is extremely suggestive of this, and the change in mineral composition involved is a simple one, frequently exemplified. I have not traced, in unbroken section, a passage from one into the other, but the scattered exposures afforded by the islands show a variation in degree of schistosity, hardness and texture, in such a way, and in such localities, as to render it highly probable that a passage of this kind actually occurs. From the localities of greenstone already enumerated in Saganagons Lake, it will be seen that of the two south-western arms, the most westerly one is eroded out of these massive rocks. From the mouth of this arm the greenstones seem to strike in a north-east direction, under the waters of the lake and reappear on the south side skirting the channel between the south shore of the lake and the off-lying islands, occurring sometimes on the main shore, sometimes on the islands and sometimes on both, disappearing altogether in the open part of the lake east of Deadman's Point.

South-west of Saganagons Lake, Jasper, Cypress, Big Rock and Emerald lakes are eroded, for the most part, out of the massive greenstones.

It is inconceivable that these hard rocks altered chemically to their most stable form, can have been the most susceptible to denuding agencies, and we are forced to the conclusion that this channel that we have traced for twenty-two miles from the west end of Emerald Lake to the east end of Saganagons Lake, must have been originally occupied by soft fissile schists, flanked for the most part by greenstones. The sinuous line of this channel, which sweeps across the main Kee-watin trough from the north side to near the south-west side, renders it improbable that these soft schists were originally the upper portion of the series, folded within the underlying traps, and it would seem more probable that this assumed schistose belt marks the plane along which the traps yielded, within themselves, to the crushing and shearing forces induced by the sharp folding of the series.

Fissile schist flanked by greenstones.

The breadth of the Keewatin series here revealed, does not afford any certain criterion by which to estimate its original thickness. The dips show an apparently simple synclinal structure of a series folded on itself. I have nowhere examined a complete section across the belt,

Thickness of Keewatin series.

This belt
branch of
belt to south-
west.

and cannot say whether the series affords any evidence of having been repeated by multiple folding or not. Again, from what is known of the distribution of the rocks on the American side of the international boundary, the hornblende granites of Saganaga Lake and Cache Bay, which from Swamp Lake sweep to the south around Gull Lake, would appear to be the south-westward ovoid termination of a large granitic area, dividing the main Keewatin trough into two branches, of which the northerly one is that seen on the Canadian side and above described, and the southerly one is seen only in a narrow tapering band of greenstones south of Gull Lake in township 65, ranges IV. and V., Minnesota, and no doubt represented, further east on the Canadian side, by the greenish-black schists of the north side of Gunflint Lake. This southern fork is largely concealed under sediments of a later age, and partly interrupted by the gabbro of the Mesabi range.

Thus the volume revealed between Saganagons and Saganaga lakes probably does not include the whole of the series, the upper members in all likelihood being wanting.

Width of belt. The distance from the contact at the Deadman's portage, across the strike, to where the line of junction intersects the north-west shore of Saganaga Lake, is four miles. The rocks dip on the north at a high angle to the south, usually about 75° , and on the south side at about the same angle to the north and are vertical at the central synclinal axis; an average dip of 85° will not be far from correct, and this would give 1.992 miles as the average thickness of the series developed in this trough.

Thickness.
South-west-
ward exten-
sion.

North-
easterly exten-
sion of Kee-
watin belt.

As before stated, this belt has been traced in connection with that holding the iron ores of Tower and Ely to the south-west. This Keewatin belt, characteristically an iron-bearing series throughout its whole length, would appear to bend somewhat sharply to the north, east of Beaver Lake, then to sweep round more easterly, with its northern limit about three or four miles south of the south-east corner of Moss Township, thence to skirt south of Greenwater and Shebandawan lakes.

Iron ores.

Iron ores, of good quality, have been found at several points in this band, and on the line of the Canadian Pacific Railway, at several points west of Port Arthur, in a broader development of Keewatin rocks, no doubt magnified by the union of several broad bands.

Small isolated
bands of horn-
blende schist.

Small isolated bands of hornblende schist, apparently included in, but quite conformable with the granitic rocks, are seen in several localities, sometimes at considerable distances from the Keewatin belt with which they would seem to be genetically identical.

Four miles and a half north-west of the Keewatin area, near Burk Lake, at a point between the north and north-east bays in the west end, occurs a band of hornblende schist, forty or fifty feet wide, in foliated pink-gray biotite granite gneiss. Large inclusions or lenticular bands of hornblende schist are seen in the pinkish-gray gneiss at the east end of Sunday Lake, two miles north-west of the main Keewatin Sunday Lake. trough. These bands would appear to indicate an original synclinal fold of the overlying Keewatin, yet the latter locality is in a direct line with the anticlinal, indicated by the diverging dips of the rocks, of Agnes Lake, two miles to the north-east, and which axis of divergence Agnes Lake. of foliation planes can be traced along the north-west shore of Louisa Lake to Farquier Lake.

Farquier
Lake.

On the second lake north-east of Farquier Lake, the red granite contains dark gray schistose hornblendic rock, with felspar, which more closely resembles a hornblende schist than a hornblende gneiss, but it may have been derived from the latter by crushing and shearing.

There is a band of coarse-grained hornblende schist, about three Lake Silence. chains wide, on the west side of the large island in Agnes Lake, one mile south-east of the outlet of Lake Silence. It also occupies a small island close to the larger one. This is interbanded with thin bands of gneiss. The rock is more coarsely crystalline and also more schistose near the contact than in the central portion of the band. This may be a crushed and sheared hornblende eruptive rock.

Included in the granitic rocks are frequently found small areas of Hornblende rock. massive, coarsely crystalline, greenish black hornblendic rock, not at all schistose, sometimes measuring only a few feet in greatest length, which appear to be scattered angular fragments included in the granites. Several such areas are seen on Agnes Lake. They are here Agnes Lake. linear in their distribution, and are seen occasionally on the islands near the west shore, from the north end of the lake to the south-west bay, where they are seen on the west shore. Large irregular fragments or areas are seen on the portage south from Shade Lake included in Shade Lake. micaceous gneiss, and they are here so frequent as to constitute the most abundant rock. From this locality, both north-east and south-west, the occurrences of this hornblende rock become less frequent, and the fragments are of smaller size, disappearing altogether about a mile each way.

Bands of hornblendic schist are also seen included in the red medium-grained granite of McNiece Lake. The granite here contains little bi-silicate, which now is mostly chlorite. On the point at the south end of Yum-Yum Lake, a local narrow band of micaceous siliceous Yum-Yum hornblende schist is also seen.

McNiece
Lake.

Yum-Yum
Lake.

Kahnipimin-anikok Lake

A coarse grained sheared hornblende rock is associated with the mica schists of the south side of the inlet of Kahnipimin-anikok Lake leading to McKenzie Lake, the most northerly one of the two deep inlets running north-east from the centre of the lake. As I shall have frequent occasion to refer to these two inlets, it will be convenient to call the north-westerly one McKenzie bay or inlet, and the one to the south-east of this Kahnawiaqamak bay or inlet.

Brent Lake.

On the south side of Brent Lake, due south of the portage leading to Conmee Lake, is a narrow lenticular band of dark gray, decomposed felspathic hornblende rock, probably lithologically allied to those already described; most of it is concealed under the waters of the lake and only a few feet of its width is revealed.

Saganagons Lake.

At the north-western extremity of Saganagons Lake is a small area coloured Keewatin, but in which the rock is a hard, coarsely crystalline hornblende rock, with occasionally a few scales of biotite, and more rarely a little felspar. It is not at all schistose, and its general aspect and mode of occurrence is that of an eruptive rock, perhaps post Keewatin in age. The extension of the rocks composing it, east and west of the channel, is a matter of conjecture.

Keewatin volcanic vent.

The small isolated areas described about Agnes and Shade lakes, on account of their diminutive size and proximity to each other, are probably highly metamorphosed fragments of Keewatin rocks, broken off from the troughs of synclinal axes, at the time that the Keewatin series was so sharply folded, and imbedded in the underlying rocks, and representing now all of the Keewatin series that denudation has spared in these localities.

Explanation of angular fragments in granite.

DIKES.

Diabase dikes.

There were not observed in the Hunters Island region, many of those "Port Archæan Diabase Traps," described by Dr. Lawson¹ and by Dr. Lawson and Mr. F. Shutt, M.A.². Indeed only two such dikes were observed by the writer, the one shown on McKenzie Inlet of Kahnipimin-anikok Lake, and the other exposed on an island lying off the east shore of the bay running north, one mile west of the mouth of this inlet. This dike is not seen on the north side of this bay and the only indication of it, south of the island, is afforded by the strong magnetic attraction observed on the point at the mouth of this bay, on the east side.

1. Geol. Survey of Canada, Annual Rep., 1887-88, Vol. III., part I., pp. 147-163 F.

2. American Geologist, vol. VII., No. 3, March, 1891.

Kahnipimin-anikok Lake,
Bay north of
McKenzie Inlet.

The island is less than one chain wide and two chains long. The whole of it is occupied by a fine-grained black crystalline diabase, which in one place, on the south-east extremity of the island, has become serpentinized. Detached hand specimens exhibit distinct polarity. As near as can be judged, the direction of the dike is a little west of south. On the west side of the island the rock becomes finer in texture which indicates the proximity of the wall. It is not seen on the south side of the lake across the channel.

The dike indicated on the map in McKenzie Inlet can be much more closely studied, particularly on the south side of the inlet, where its contact with the inclosing mica schists is clearly seen. McKenzie Inlet dike.

The differentiation in texture between the wall and the centre, which is such a characteristic feature of these dikes was observed. The rock is a fine to coarse-grained, black, weathering pepper and salt gray, crystalline diabase. The width of the dike is sixty feet. Its course from the exposure on the south to that on the north side is due north, which is also the direction of the walls on the south side. It would not appear to extend very far south, as it is not seen in this direction, this, however, may be accounted for by the prevalence of drift in some of the localities where it might be expected to occur. It cuts the Laurentian rocks on the north side of the inlet, and the Couthiching Age of dikes. on the south, in such a way as to leave little doubt that it was intruded since the period of the last folding, which on the assumption that the Couthiching and Keewatin rocks were folded at the same time, would establish their geological age as post-Keewatin.

Other dike-like masses have been alluded to in previous pages, but Other dikes. they are not lithologically allied to these diabases, and their intrusive character is but conjectural.

GLACIAL PHENOMENA.

The remarks made by Dr. Lawson in his report on the Lake of the Woods region, in the annual report of the Geological Survey for the year 1885, Part CC, and on the Rainy Lake region in the annual report for 1887, Part F, are generally applicable to this region also ; the same features of glaciated surface, exhibiting generally rounded hill features and *roches moutonnées*, with the prevalence of drift, usually gravel, on the sides of elevations away from the direction from which the ice moved, are met with here. But while the broader features of glaciation are not less general or less marked in this region than in those reported on by Dr. Lawson, the minuter features of striations and groovings of the rocks are neither such conspicuous or universal Roches moutonnées. Glacial drift. Glacial striæ less frequent.

Profound
glaciation of
Coutchiching
rocks.

Preservation
of striæ in
different rocks

Striæ in Sand
Point Lake.

Sturgeon
Lake.

Pooh Bah and
Hoffmann
Lakes.

Russell Lake.

Lake Silence.
McIntyre
Lake.

features/ as in those districts ; indeed in the area embraced in the western half of the accompanying sheet such indications are extremely rare, and only one observation is recorded. This is no doubt due to the prevalence of mica schists in this portion ; the comparatively soft and friable nature of these rocks has no doubt yielded so readily to aerial influences, as to obliterate the striations in the period that has elapsed since glacial times ; but the comparative evenness of this part of the country in minute superficial features as in great, attest that these rocks have yielded more profoundly, and have been planed to a greater uniformity of level by the passage of glacier ice, than have the harder granitic rocks of the Laurentian and eruptive and even schistose rocks of the Keewatin series.

The only striation recorded in the western part of the sheet, occurs in the felsitic granites of Sand Point Lake ; which is in accordance with the general rule that the granitic rocks preserve the striations for longer periods than the mica schists. In this region the Keewatin rocks have preserved the striations with still more clearness and persistency than the granitic rocks.

Nearly all the striæ observed are represented by a conventional sign which indicates their direction ; and from these we can gather an approximate estimate of the general direction of ice movement.

The single observation near Sand Point Lake indicates that there the direction of movement was S. 28° W.

In the neighbourhood of the western part of Sturgeon Lake the directions of the striæ vary from S. 3° W. to S. 22° W. ; and the average direction of the greater number of the striæ is about S. 20° W. ; south of this on Hoffmann and Pooh-Bah lakes, the same direction is indicated by striæ not recorded on the map.

In the neighbourhood of the middle part of Sturgeon Lake, the striæ vary in direction from S. 17° W. to S. 30° W. ; and in the vicinity of the eastern part of this lake and of Russell Lake they vary from S. 2° W. to S. 32° W. ; both extremes doubtless represent local deflections in ice movement due to local inequalities, and may be neglected in computing the general direction of movement, which would appear to be from S. 17° W. to S. 23° W.

Two observations in the shores of the McKenzie inlet of Kahnipi-minanikok Lake give S. 27° W. and S. 29° W., and a third observation not recorded on the map indicates a direction of S. 17° W.

Single observations on Lake Silence, and at the north end of McIntyre Lake, give directions of S. 19° W., and of S. 12° W., respectively.

The striæ observed on Knife, Emerald, and Carp lakes, and on The Knife, Emerald, Carp and Other Man's Lake, vary between extremes of S. 10° W. and S. 38° W., and the general direction is S. 23° W.

On Cypress and Jasper Lakes, and on Cache Bay of Saganaga Lake, Cypress, Jasper and Saganaga lakes (Cache Bay). the striæ range between S. 10° W. and S. 28° W., and the most common direction is nearly the mean of these two, or S. 20° W.

In the vicinity of the western part of Saganagons Lake, the direction of ice movement has varied from S. 15° W. to S. 32° W.; and on the eastern part of the lake the movement has diverged very little from S. 20° W.; a local variation north of this is indicated on Beaver Lake, by striæ bearing S. 8° W.

At a locality on the south shore of Saganagons Lake, near the middle, two sets of striæ were observed intersecting each other; but from the indistinctness of both sets it could not be determined with certainty which was the more recent. One set has a direction of S. 43° W. and the others bear S. 23° W.

Mr. Robert Chalmers of this department in his paper on the "Glaciation of Eastern Canada,"* says: "The divergent courses of striæ, often seen upon the same rock surface, are, however, sometimes explicable on the theory of their having been produced by successive portions of the diminishing glaciers, conforming in their motions more closely to the surface features, during the period of melting." From the rarity of occurrence of this phenomena it would seem to be accounted for with more probability on this assumption, than by supposing these intersecting striæ to indicate the passage of two successive fields of ice at important intervals of time.

Roches moutonnées, well marked and prominent, form a conspicuous feature of shore surface in Kahnipiminanikok Lake and elsewhere, and prove the south-westerly flow of the ice. The direction of their axes (about S. 42° W.) appears to be rather a function of the structure of the rock, with whose strike it agrees, than of the direction of movement of the ice; which movement so far as observed in this region is never so westerly in its course.

It will be seen from the above records that over this whole area the General direction of the ice flow has varied between extreme limits of S. 2° W. and S. 39° W.; and that the general direction is roughly S. 20° W.

Dr. Lawson calculated the average direction of the ice flow in the Rainy Lake region† to be about S. 40° W. and in the Lake of the Woods region‡ to be about S. 45° W. These diverging directions are

* Canadian Record of Science. April, 1889.

† Geol. Survey of Canada, Annual Rep., 1887-88, vol. III., part I., p. 164 F.

‡ " " " " 1885 " I., p. 138 CC.

doubtless a function of the direction of the general slope of these different portions of the country in glacial times, and would indicate that the glaciers have been shed from the higher northern slopes of the Archæan nucleus, in varying directions normal to the periphery of this nucleus, and determined by the general slope of each region, as suggested by Mr. Chalmers in the paper above quoted.

Erratic boulders.

Boulders transported by ice are not uncommon, but none were observed which by their composition indicated that they had necessarily been carried from any great distance.

South-east arm of Sturgeon Lake.

A curious boulder of granite, weighing many tons, and evidently transported by ice for some distance, rises ten or twelve feet out of the water in the middle of the first expansion, south of Sturgeon Lake, of the south-east arm. The under surface sloping out of the water is finely striated and the corners and edges well rounded.

Sometimes the surfaces of the rocks are seen to be indented by curious cracks in the shape of the arc of a circle and concentric with each other. These "chatter cracks" are doubtless caused by a large boulder being forced over the surface by an inclosing ice sheet, in which it is held very tightly, and in such a way that it cuts the surface of the rock for a short distance, then slips to catch the surface again a few inches further on. An instance of this kind occurring in Basswood Lake is figured in Plate IV.

ECONOMIC GEOLOGY.

Land suitable for farming.

No actual lumbering has been done in this part of the country. The forest trees have been already referred to. While the portion of Western Ontario depicted on the map which accompanies this report, offers practically no inducement to the agricultural settler, it is by no means devoid of areas covered by post glacial drift deposits, which would yield good crops for the sustenance of settlers led there by other interests, such as the miners, and for this purpose there is good land amply sufficient to fulfil all the possible requirements for many years.

Farming land in Indian reserves.

The largest drift areas, and those conspicuously the best, from an agricultural stand-point, have been granted to the Indians, and are for the most part included in the boundaries of Reserve D and Reserve 24C. The soil of the western part of the former is a sandy loam, but the eastern half is characterized as wild lands, and does not offer many agricultural facilities. The latter I have not visited in person, but I am informed that in the valley of the lower part of the Kawawiagamak River good farming land occurs.

Much good land in separate areas, sometimes of considerable extent, is seen in the whole valley of the Maligne River, including both shores of Tanners Lake, and extending in a broad belt along both sides of the river.

Very good land is also afforded by the alluvial drift near the mouth of the Namakan River, on the north side. North of Namakan Lake, in the western part, are also some areas of drift which would be worth cultivating if a market for the products were provided.

It is generally assumed that Laurentian and Couthiching rocks do not contain metalliferous veins; narrow and subordinate veins of quartz do occur in the rocks of both these series, but they are as a rule not very persistent, and have not been found to contain any mineral, with the one exception of the molybdenite bearing quartz vein of the Bears passage of Rainy Lake, described by Dr. Lawson in his report, Vol. III., Part I.; 1887-88, p. 181 f. Granites in the neighbourhood of its contact with Keewatin rocks frequently contain valuable veins.

Namakan
River and
Lake.

Barrenness of
the Lauren-
tian and
Couthiching
series with
regard to
metalliferous
deposits.

Quartz veins are more abundant, larger and more important in rocks Quartz veins. of the Couthiching series, than in the underlying rocks; and some of them may yet be found to contain economic quantities of precious metals. The writer has since found low grade magnetic iron ores in rocks probably of Couthiching age. In the rocks of these series Mica. however, one mineral may be hopefully looked for. The mica of the pegmatite patches, veins and dikes, is of excellent quality; while on the surface I have seen no sheets of considerable size, it is not unreasonable to hope that beneath the surface, below the level of aerial influences, sheets sufficiently large to be of commercial value will be found.

The iron ores of the Keewatin belt of rocks, indicated on the south-eastern part of the sheet, have been already referred to at considerable length. These would appear to offer the brightest promise of future mining activity of any iron ores known between Lake Superior and the Lake of the Woods. The iron ores of the Atikokan River are very promising; but for these no other worked deposits, quite similar in occurrence, afford criteria by which their value can be more closely estimated, such as the mines of Tower and Ely afford for the estimation of the Hunters Island ores.

Additional prospecting, in the rocks of this Keewatin belt, will very likely be rewarded by the discovery of gold-bearing veins, as well as occurrences of other minerals.

In 1866 there was considerable excitement over the discovery of auriferous quartz in the Keewatin schists of Vermilion Lake in Minnesota. From twenty to thirty dollars of gold to the ton of quartz was

assayed from specimens brought in.* The gold-bearing quartz of the Lake of the Woods occurs generally in rocks of Keewatin age, but the veins of the "Sultana," "Ophir" and other mines of this district occur in granitic rocks, which the writer is inclined to regard as later post-Keewatin eruptives, but which may be of Laurentian age. The gold-bearing veins discovered north of the Atic-Okan and Seine Rivers, in the district north of that to which this report refers, occur in quartz-porphyrries (often very similar macroscopically to the coarse grained granites of the Lake of the Woods in which the gold-bearing veins occur) and which are very probably post-Keewatin in age.

The development of the great mineral wealth of this country is hampered by the entire lack of transportation facilities and is retarded by a spirit of petty speculation encouraged by laws which make clever speculation more immediately lucrative than active mining.

* *Vide* 18th Annual Rep. of Minnesota, p. 19.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON THE

GEOLOGY AND ECONOMIC MINERALS

OF THE SOUTHERN PORTION OF

PORTEUF, QUEBEC, AND MONTMORENCY COUNTIES

PROVINCE OF QUEBEC

BY

A. P. LOW, B.Ap.Sc.



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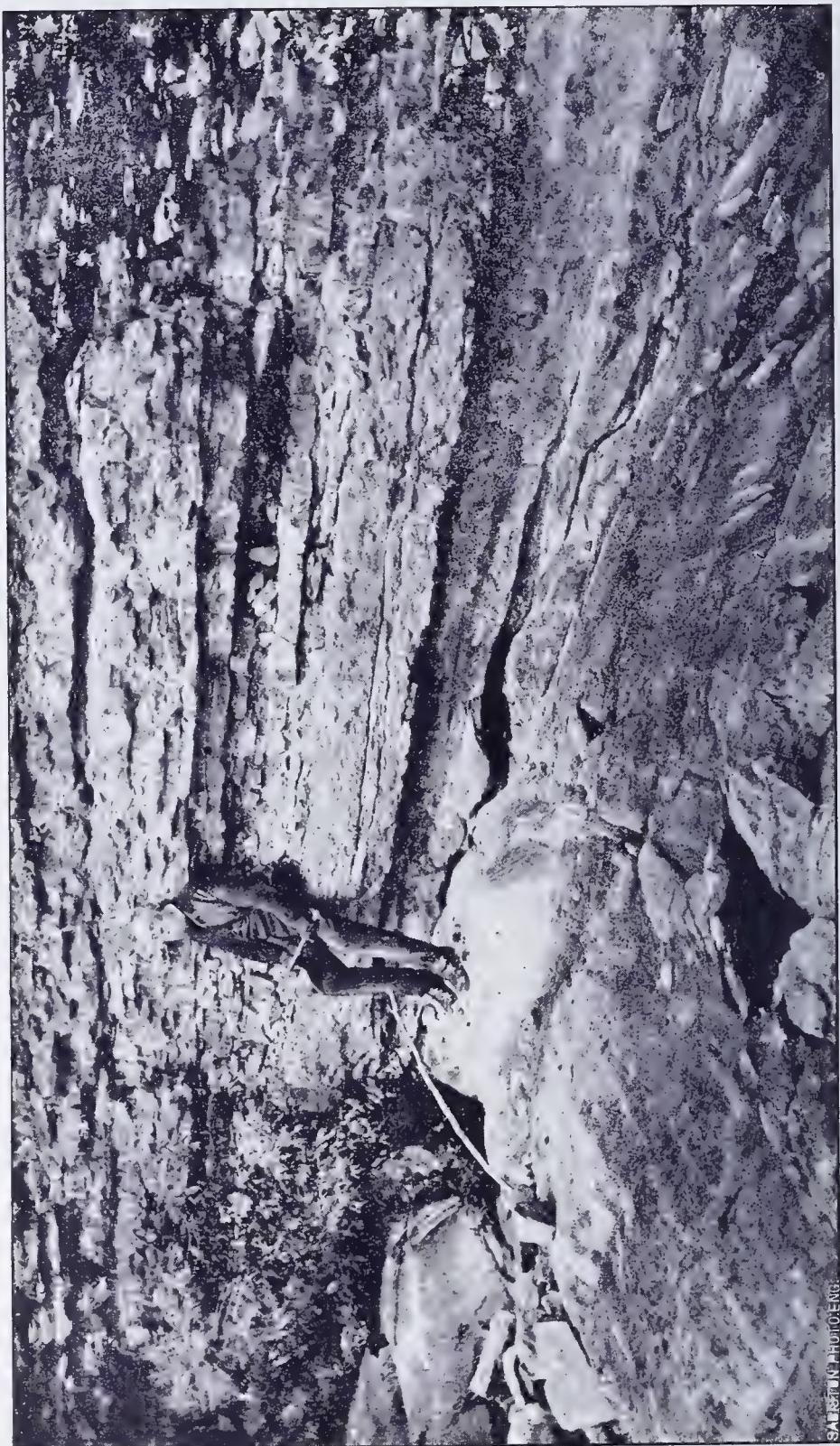
To ALFRED R. C. SELWYN, C.M.G., F.R.S., LL.D., &c.,
Director of the Geological Survey of Canada.

SIR,—I have the honour to herewith submit my report on the geology and economic minerals of that portion of the counties of Portneuf, Quebec and Montmorency, included in the north-east sheet of the Eastern Townships map.

I have the honour to be, sir,
Your obedient servant,

A. P. LOW.

NOTE.—The bearings given throughout this report refer to the true meridian.



SAFETY PHOTOENG.

From Photograph Presented by Mr. C. D. Walcott, U. S. Geol. Surv., 1891.
UNCONFORMABLE CONTACT OF GNEISS AND TRENTON LIMESTONE; A HALF-MILE UP FROM MONTMORENCY FALLS Q.
Dr. SELWYN IS STANDING ON THE GNEISS AND IS LEANING AGAINST THE LIMESTONE.

REPORT
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GEOLOGY AND ECONOMIC MINERALS
OF THE SOUTHERN PORTION OF
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BY
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The following report is the result of an exploration during the season 1889 in that portion of the province of Quebec embraced in the north-east sheet of the Eastern Townships map, north of the St. Lawrence River, comprising the southern portions of the counties of Portneuf, Quebec and Montmorency. This area is triangular in shape, and is bounded on the west by a line running north from one mile west of Grondines Point on the St. Lawrence, west long. $72^{\circ} 04' 40''$, and passing through the seigniories of West Grondines, East Grondines, La Chevrotière, Tesserie and Perthuis, and the townships of Alton and Colbert, in all, thirty-five miles in length. The northern boundary is on the $47^{\circ} 05'$ parallel of latitude ; it is sixty-two miles long, and cuts the St. Lawrence in the parish of St. Joachim, near Cape Tourmente. The southern and eastern boundary is the north shore of the St. Lawrence River from Grondines to Cape Tourmente.

The total area is twelve hundred and seventy-five square miles, the northern part of which nine hundred and eighty square miles is occupied by Archæan rocks, with a narrow irregular margin between their southern limit and the St. Lawrence, occupied by Cambro-Silurian limestones and shales.

The physical features of the country depend to a great extent on this distribution of the rocks, the Archæan area being high and mountainous, while the Cambro-Silurian area is comparatively low and flat. The greatest elevation is towards the north-east, where the country rises abruptly into an uneven plateau, with a general elevation of over

fifteen hundred feet above sea level, while rounded hills rise above the plateau to heights in places exceeding five hundred feet.

Small lakes This plateau is cut by numerous river valleys, all of which take their rise from innumerable small lakes on the watershed between the St. Lawrence and the Saguenay rivers, mostly to the north of the sheet. The general elevation decreases slowly from east to west, being from one thousand to twelve hundred feet at the north-western limit of the map, but even here many of the higher points rise to elevations of two thousand feet and upwards.

Difference of level.

The country slopes gradually towards the south in the western part of the sheet, where near the boundary between the older and newer rocks the general elevation does not exceed three hundred feet, and the hills rising above the average level are fewer and lower than to the northward, while the river valleys spread out and are filled with broad flat deposits of terraced, stratified sands, gravels and clays. The outline of the boundary between the gneisses, and the limestones and shales is irregular and usually easily defined, as the country drops suddenly on passing from the older to the newer rocks, and from there to the St. Lawrence River presents a comparatively low, flat surface. Along the western portion of the boundary the marked subsidence is wanting, as both series of rocks are covered by deposits of sand and clay.

Rivers.

The principal rivers draining this area are the Ste. Anne de la Pérade, Portneuf, Jacques Cartier, St. Charles, Montmorency, Sault à la Puce and Ste. Anne de Montmorency. Of these the Ste. Anne de la Pérade, Jacques Cartier and Montmorency, taking their rise beyond the northern limit of the map, are the longest and largest. A curious feature is the course of the former two, they flow from north-east to south-west, or at an angle of about 150° to the course of the St. Lawrence into which they empty ; this westward flow is not so marked in the other rivers, but they all possess that tendency.

The valleys in the Archæan area are in a general way parallel to the strike of the rocks and consequently have a roughly north and south direction.

Previous explorations.

Previous to the present exploration little work had been done on the Archæan area, but the southern country underlain by the Cambro-Silurian rocks has been accurately reported on by Sir Wm. Logan in the Report of Progress of the Geological Survey of Canada, 1852-1853, of which a complete summary is given in the Geology of Canada, 1863.

More recent work has been done in parts of the same area by Rev. J. C. K. Laflamme, Annual Report, Geological Survey of Canada, 1886, pages 36A, 38A, and Annual Report, 1887-88, pages 31A 32A, also

by Dr. R. W. Ells, assisted by N. J. Giroux and H. M. Ami, Annual Report, 1887-88, pages 18 $\frac{1}{2}$, 25 $\frac{1}{2}$.

ARCHÆAN.

Investigations in this northern Archæan area are made at great disadvantage owing to its rough and broken character.

The rivers falling from the high interior plateau are much broken by rapids and falls, and owing to their rapid descent are liable to great and sudden variations in volume of discharge, and are, therefore, only navigable with canoes on their lower courses. The valleys of the rivers and their tributary streams are deep, with almost perpendicular walls, rendering cross country travel very arduous and in places impossible, while the dense forest growth adds to the difficulties and hides many of the rock exposures.

Except the poor roads which follow the principal river valleys no means of travel exist, and, consequently, the observations on the geology of the region are in the main confined to these valleys.

As before stated the southern boundary of the Archæan is irregular, several spurs projecting from the main mass southward giving it a sinuous outline. Of these spurs the Deschambault, Pointe aux Trembles and Montmorency are the most marked, and have an important bearing on the deposition of the Cambro-Silurian rocks upon them.

Starting from the western limit of the sheet the Archæan rocks are seen on the west side of the Ste. Anne de la Pérade River, and crossing it at Gorrey's fall, twelve miles north from the St. Lawrence, continue on an east course until they touch the road between the fourth and fifth ranges of Portneuf; here they turn immediately south, between the La Chevrotière and Belisle rivers to the back of the third range of Deschambault, where they cross the latter stream and run south-east between it and the road passing back from Deschambault village, to within one mile and a-half of the St. Lawrence. From here they turn north 50° east and pass in rear of the second range road behind Portneuf village, and from the highland on the west side of the Portneuf River, which they cross in the parish of St. Jacques and then sweep round to the southward crossing the Jacques Cartier River a short distance above Ste. Jeanne de Neuville, where the course again changes slightly to the north and passes into the third range of Fossambault, here an abrupt turn to the south brings them within two miles of the St. Lawrence in the high land behind Pointe aux Trembles village, where the course again changes to N. 50° E. and continues thus through the village of Lorette to the Montmorency River where they

Irregular southern boundary.

again turn south and outcrop in the bed of the river at the Falls. Thence eastward they run almost parallel to the St. Lawrence again approaching it at Château Richer, beyond which they sweep more to the northward crossing the Ste. Anne River three miles inland and then again reach the coast at the limit of the map near Cape Tourmente.

Generalstrike. The general strike of the Archaean rocks is from ten to twenty degrees west of south in the northern part of this area, while in the southern and western portions they sweep around to the westward and have an average strike of S. 50° W.

General Divisions of Archaean Rocks.

General section. Before entering into a detailed description of these rocks, it is proposed to give a rough section across the northern portion, and consequently nearly at right angles to the general strike. This section runs from Lake Simon on the west to the eastern extremity of the area, and is so made on account of the greater number of exposures near it than on any line run directly east and west.

In this section the rocks are grouped in accordance with the predominating rock, and although no mention is made of them, bands of other varieties, of lesser importance and extent, are included in all of these rough divisions.

From the western limit of the map the section is as follows :

(1) Dark schistose mica gneiss, interbanded with coarser red and grey mica gneisses.	10	miles.
(2) Fine banded grey, pink and red mica and mica-hornblende gneisses.....	10	"
(3) Dark grey garnetiferous hornblende gneiss	2	"
(4) Fine banded grey, pink and red mica and mica-hornblende gneisses.....	7½	"
(5) Dark green basic, crushed granitic gneiss.	1½	"
(6) Coarse red and grey augen-gneiss.....	2½	"
(7) Fine banded gneiss (2) and (4)	6	"
(8) Coarse red and grey augen-gneiss.....	6	"
(9) Fine banded grey and pink mica-gneiss...	14	"
(10) Anorthosite.....	2	"
(11) Fine banded grey and pink gneisses	12	"

The rocks of divisions 1, 2, 3, 4, 7, 9 and 11 appear to have been originally clastic rocks, subsequently completely metamorphosed and subjected to great pressures, which have folded and twisted them so

that their original horizontal succession is greatly obscured, while their composition has been changed into the material of schists and gneisses. As these rocks are very old, if they were originally laid down as clastic rocks, the conditions of deposition must have been greatly different from those which prevailed in later times, when carbonate of lime formed one of the chief materials deposited; whereas in these older rocks it is markedly absent; quartz, orthoclase, mica, hornblende and plagioclase being the principal components, and what they may be the products of is difficult to say. There is at present no reason for dividing the above rocks into more than one group of the Laurentian, as they seem to be separated from one another by no unconformity, and the different bands appear to grade into one another, the difference of composition being local. The fifth division embraces rocks of probably igneous origin, which have been injected along a line of weakness between the banded gneisses and the coarser-grained rocks of the sixth division. Smaller areas of a similar rock occur along the north branch of the Ste. Anne and to the south-east of the anorthosite area.

The sixth and eighth divisions are coarse-grained rocks, showing in places gneissic structure, but often granitic. They appear to underlie the banded gneisses, and are either the remains of older beds that have been re-fused, or are original molten matter from the interior which has dissolved and floated portions of the banded beds, and, as fragments of them are inclosed in the coarser gneisses, have cooled subsequent to the deposition and hardening of these banded gneisses. The anorthosite is also of igneous origin, having been apparently intruded into its present position after the formation of the banded gneiss with which it is in contact. This contact is not so sharp as in many localities and is difficult to map, as the gneisses near it seem to have been infiltrated by basic felspar material from the anorthosite, causing the passage from the one to the other to be gradual.

Division I.

The rocks of this division are best seen in the cuttings along the line of the Quebec and Lake St. John railway.

Starting from the western limit of the sheet, near the bridge over Black River, and following the line eastward, many exposures are seen in the cuttings and on the hillsides south of the track, but as the railway runs nearly parallel to the strike, only a small cross section is obtained.

Quebec and
Lake St. John
railway.

A highly contorted dark grey micaceous, schistose gneiss predominates; most of the bands contain quantities of black hornblende

associated with biotite, sufficient in some cases to change the rock into a hornblende schist; all the bands contain more or less grey translucent quartz and pink and grey orthoclase. Small dark red garnets are present in many of the bands, also small disseminated grains of magnetite, to the decomposition of which the rusty weathered appearance of these bands may be due.

Lenticular
masses of
hornblende.

Associated with the above are bands of coarser pink and light grey mica-hornblende gneiss, often holding lenticular masses of schistose black hornblende. These lenticular masses frequently follow one another in bands, and have the appearance of having been stretched and broken while inclosed in a softer surrounding mass. A less marked shattering of basic bands inclosed in a more acidic mass is frequently seen in these rocks, where the dark band has been unevenly pulled out, during which operation it has reached the tensile limit under the conditions and become broken into angular fragments. The cracks between these have been filled by the softer matter of the inclosing rock, showing that at the time of the pressure and motion the acidic rocks were in a sufficiently fluid condition to be pressed into all the cavities formed by the breaking of the more basic rock which apparently continued in a much more solid state. Fragments of the basic rock, with their angles more or less rounded by the dissolvent action of the fluid magma in which they were inclosed, are often found floated away from the band to which they belong.

Segregations
of hornblende
and mica.

Hornblende and mica segregations, generally of an oval form, are also common in these rocks and are often hard to distinguish from the broken lenticular bands, but are apparently formed in a different manner by the segregating of the mineral from the surrounding magma, which is generally found to be remarkably free from the segregated mineral. These segregation masses sometimes have a concentric structure, and occasionally show a difference in hardness and colour between their outside and inside laminæ.

Pegmatite
veins.

All these bands are everywhere penetrated by coarse pegmatite veins composed largely of cleavable masses of pink orthoclase, holding rounded masses of quartz and inclosing crystals of mica and hornblende, with magnetite and haematite in some cases. The mica crystals are often of large size, but nearly always badly contorted and bent, rendering them useless for economic purposes.

Origin of
pegmatite
veins.

These pegmatite veins appear to have been formed in the cracks of the surrounding rocks, by a solfataric action, from saturated highly heated waters under high pressure, and not like the basic dykes which are met with occasionally in the same rocks and which have clearly been injected into the later cracks in a molten state. Exposures of

these rocks continue along the railway line to Allan's mill station. One mile east of Allan's mill the line bends southward around the base of a rocky hill. Here the rock is a fine-grained grey granitoid gneiss, while a short distance southward, on the road east of the track, exposures occur of a medium-grained micaceous granitic gneiss, deeply weathered on the surface and on a fresh fracture of a light pink colour. Along with this is a very fine-grained pink highly quartzose granitoid gneiss holding small light red garnets. This is followed by bands of highly contorted coarse grey gneiss, rich in white orthoclase and mica. The next exposures along the railway are at the crossings of the road running between the third and fourth ranges of Bourg Louis. Here medium-grained highly felspathic mica-gneiss is interbedded with dark grey micaceous gneiss.

One-quarter of a mile beyond, a small cutting is made through a fine-grained blackish hornblendic schist, composed chiefly of black hornblende and greenish triclinic felspar and a small quantity of quartz. A small dyke of dark green fine-grained diabase cuts this Diabase dyke. rock. No exposures are now seen along the line for a mile, when a small cutting shows fine-grained highly quartzose gneiss with small quantities of pink orthoclase and brown mica.

Division II.

Division 2 extends from the east side of the Ste. Anne River to Distribution[•] near Lake St. Joseph. Roads run up on either side of the North Branch of the Ste. Anne River; that on the west side crosses the river <sup>North Branch
Ste. Anne
River.</sup> and joins the east road about the middle of the seventh range of Gosford; while the latter continues on to the upper forks, near the northern limit of the map. Passing southward from its end the first exposure occurs one-half mile below, where the rock is a brownish, weathering, medium-grained mica-gneiss. The next is where the road crosses the line between the second and third ranges of Rochmont; and here the rock is a fine-grained pink mica-gneiss. An exposure of similar rock associated with coarser-grained bands occurs on the hill at the Roman Catholic chapel.

From here to the junction with the road on west side stratified sands and gravels are passed over, with rocky hills from two to six hundred yards to the eastward, composed chiefly of medium-grained light grey mica-gneiss.

A short distance below the junction of the roads is the last exposure of these rocks. The hills then run eastward toward the main river, and the road from there to the river passes over a broad sandy plain, with terraced faces towards the rivers.

West side of
North Branch.

The road on the west side from the bridge near its junction with the east road passes immediately over a drift-covered hill of fine-grained pinkish grey granitic gneiss, the colour varying with the proportion of mica present in the bands. From here to the Mauvaise River bridge, the road passes along the side of the mountain, forming the western boundary of the river valley ; the rock outcrops in a number of places in this distance, and is a medium-grained grey granitic gneiss, with a few pink bands.

Just south of the Mauvaise River and forming the point between it and the North Branch is an isolated, rounded hill, made up chiefly of coarse red and grey mica-hornblende granitic gneiss. The other exposures, seen to the east of the Ste. Anne River, are along the roads between ranges two and three, and ranges three and four of Bourg Louis West ; also on the Jacko River, in range B.

The first of these roads is continued beyond the third range and forms the route road to Lake Simon, running for the greater part of its western half near the railway line. The first exposure seen on it westward from the Ste. Anne River is on the hill one mile east of Allan's mill, and has already been described in connection with the railway section. In the second range, one mile north of the last, are medium-grained grey and pink mica-gneisses associated with a brownish grey mica-hornblende granite. These rocks are highly contorted on the strike and appear to be near the great bend, where the strike changes from south to south-west.

West side of
Ste. Anne
River.

Lake Simon.

At Allan's mill, one-quarter of a mile south of the railway, fine grained light grey mica-gneiss outcrops in the river, while at the crossing of the discharge of Lake Simon, one-quarter of a mile from the lake, these rocks are found associated with a coarser grained variety of the same rock ; the finer grained holding considerable quantities of small dark red garnets. At the bridge of the Jacko River, in range B, of Bourg Louis, the rock is a fine-grained dark grey schistose mica-gneiss, similar to that found along the railway. On the North Branch of the Ste. Anne River, two miles below the upper forks, and at intervals for one mile and a-quarter below, are exposures of coarse-grained greyish gneiss, composed of white orthoclase, quartz, black mica and hornblende, and containing grains of magnetite ; on exposed surfaces the rock weathers a rusty brown. Where the river crosses the line between ranges eight and nine of Gosford, on the west bank, is an exposure of medium-grained dark flesh-red gneiss, highly quartzose, with dark red orthoclase and black mica. One-quarter of a mile farther down stream, the rock is a very fine-grained light pink gneiss, highly quartzose with small quantities of pink orthoclase and

black mica in a finely divided state ; the rock approaching an impure quartzite, and penetrated by small veins of light green epidote.

In crossing range six of Gosford the river passes through a narrow rocky gorge half a mile long, with a descent of over 60 feet, including a direct fall of 30 feet. Here the rock was found to consist of a medium-grained dark greyish-green basic granitic gneiss, made up of greenish Basic gneiss. triclinic felspar and black hornblende with little quartz, and a considerable quantity of finely divided pyrite. Banded with this rock is a dark pink coarse-grained gneiss composed of orthoclase, quartz, black hornblende and some biotite.

Near the point where the river crosses the line between Gosford and Bourg Louis, a heavy rapid is caused by an outcrop of dark red fine-grained schistose mica-gneiss, greatly contorted and penetrated by small veins of green epidote. One mile and a half below the last, and continuing down stream for half a mile, are exposures of dark red medium-grained gneiss, composed of red orthoclase, quartz and biotite. These are followed by thin bands of pink and grey fine-grained orthoclase-biotite-gneiss, with many of the dark bands composed almost wholly of mica. Below these exposures the river passes between steep banks of sand, gravel and clay, and no rock is seen to the junction with the main river. The main branch of the Ste. Anne River crosses the line between St. Ignace and St. Gabriel at the north limit of the map where it descends in a succession of chutes 150 feet. Here is a pink fine-grained gneiss composed of light pink orthoclase, greyish translucent quartz and dark mica ; the mica, forming the chief constituent, is arranged in thin bands from one-half to one inch apart which gives a fine banded structure to the rock mass.

On the north side of Markham pool, two miles and a-half below the falls, the mountain rises precipitously 1,000 feet above the stream, its face is covered with a dense forest growth and the few rock exposures are difficult of access. From the small exposures seen here gneiss similar to that above appears to be interbedded with a more basic variety which weathers a rusty grey from the decomposition of the iron present. On a fresh surface its colour is greenish-grey, and the minerals composing it are a greenish triclinic felspar with small quantities of dark hornblende and quartz.

Near the mouth of the Jambon River, a tributary from the north, the Ste. Anne flows close to the base of the high hills on the north west side, and a large mass of fallen rock has cleared out the forest from an elevation of 200 feet to the perpendicular cliff. Here large fresh surfaces of fine-grained grey and pink gneiss are exposed ; the constituent minerals being pink and grey orthoclase, and moderate

quantities of quartz and biotite, the latter arranged in thin bands from one-quarter to one-sixteenth of an inch apart.

The next outcrop on the river occurs one mile and a-half above the east line of Gosford, where a coarse-grained dark flesh-red orthoclase mica-gneiss was observed. Near the mouth of the FitzCharles River, a small tributary from the south, in the fourth range of Gosford, is a fine-grained grey gneiss, composed of grey orthoclase, black hornblende and quartz, and penetrated by small pink pegmatite veins.

At the mouth of the Talayarde River, and for some distance below, the river descends over a number of rocky ledges forming a heavy rapid. Here the rock is chiefly a flesh-red gneiss, made of dark red orthoclase and biotite, varying in structure from coarse to fine grained, the coarse grained predominating. Interbanded with this red gneiss are thinner masses of a grey colour, the difference of colour being due to the orthoclase, which in the grey bands is a dirty white.

Below this the river valley, which has not been over a half mile wide, and bounded by high steep cliffs, widens out, and the stream flows in a crooked channel between cut banks of stratified sand and clay until Jackson's mill is reached, one mile and a half below its junction with the North Branch. Here the river falls thirty feet over a ledge of medium-grained grey micaceous gneiss, holding numerous small dark red garnets, and penetrated by large veins of pink pegmatite, inclosing masses of rounded quartz and broken crystals of mica.

The next exposure is three-quarters of a mile below, where a small rapid is caused by an outcrop of coarse-grained pink gneiss, composed of grey and pink orthoclase, quartz and biotite, banded with a fine-grained highly quartzose mica-gneiss.

One mile and a half below this the river takes a bend to the westward, and flows in that direction three miles to Ford's mill, crossing the line between Bourg Louis and D'Auteuil. For the first three-quarters of a mile the river passes over a number of rocky ledges with considerable fall, forming Kelley's rapids. At the upper end the rock is a fine-grained pink gneiss, holding many small red garnets. At the lower end a very fine-grained pink gneiss, highly quartzose, with pink orthoclase and little mica, prevails, and associated with this are thin bands of dark mica-schist, which have been apparently segregated from the surrounding rock. These bands are very much shattered and faulted. At Ford's mill the river falls twenty-five feet over a fine-grained grey gneiss, approaching mica-schist in structure, being composed chiefly of that mineral, along with thin bands of pink orthoclase-gneiss, and quantities of impure pink quartzite. All are penetrated by pink pegmatite veins.

Lower Ste.
Anne River.

Kelley's
Rapids.

The next exposures occur at the bridge crossing the river, near the line between Jacques Cartier and Portneuf seigniories. From this point to Gorry's mill, a distance of six miles, the river is a succession of heavy rapids and falls. Along this portion exposures of gneiss outcrop in the river at short intervals, and everywhere were found to be of the same character as those described above ; the greater part being dark grey schistose gneiss, composed chiefly of mica, with grains of quartz and orthoclase, interbedded between the plates of mica which curve around the grains.

Along with the schists are thinner bands of pink orthoclase-gneiss, and fine-grained highly quartzose pink gneiss, nearly free from mica. In many places veins of pegmatite, varying from one to several feet in width, cut the different bands. In one large vein of this kind, a Pegmatite mile and a half below the mouth of the Jacko River, crystals of veins. quartz, black mica, dark red garnet, black hornblende and haematite were found scattered through the mass of orthoclase.

At Gorry's mill the river has a sheer drop of ninety-five feet and below this no rock exposures occur in the winding valley for four miles and a half, when an outcrop of Cambro-Silurian limestone crosses the stream ; the distance in a straight line between the last gneiss and the first limestone is one mile and a half. Along the road on the east side of the Ste. Anne River, in the fourth range of Gosford, four exposures of dark grey mica-gneiss occur with a general strike of N. 15° E., while to the south along the road between Gosford, Fossambault and Bourg Louis, these rocks associated with broad bands of light pink, fine-grained, highly quartzose, hornblende-gneiss, holding minute garnets and grains of magnetite, bend round to the westward with a general strike of S. 80° W.

The grey gneisses are again seen one mile south of the river on the road along the second range of Bourg Louis.

From here westward and southward to the limits of the Archæan the south side of the Ste. Anne River is occupied by a broad flat terraced sandy plain varying from two to five miles wide and bounded on the south-east side by the low hills of the Deschambault spur of the gneiss, Deschambault which in its southern extension, as has been already stated, reaches to spur. within one mile and a half of the St. Lawrence.

The rocks of this spur, and its eastern extension, are seen in numerous exposures along the roads running back from the St. Lawrence. They show generally fine-grained grey and pink orthoclase-biotite gneiss arranged in alternate thin bands, the grey being the most common, and often containing black hornblende in association with the mica, while the red is formed chiefly of red orthoclase and quartz. Both varieties

often hold small dark red garnets. Associated with these fine-grained bands are some of coarser texture. In a few of the latter, as seen on the road between D'Auteuil and Jacques Cartier, where it turns westward one mile south of the bridge over the River Claude, grains and small splotches of magnetite are common ; and similar rock is seen on the road between the parishes of St. Paul and St. Charles in Portneuf, where the rock is a highly contorted coarse-grained very ferruginous gneiss.

Towards the Jacques Cartier River, in the parish of Ste. Marie, a broad band of coarse pink granitic augen-gneiss occurs ; and this or a similar band is seen on the east side of the Portneuf River immediately north of the Quebec and Lake St. John railway, where the hills have been burnt over and large exposures laid bare. Here the augen-gneiss is generally light grey in colour and composed of thin bands of black mica inclosing partly developed crystals and lenticular masses of grey and pink orthoclase, varying in thickness from one-eighth to one-half an inch in thickness and from half an inch to an inch and a half in length, the longest axis being parallel to the plane of foliation. The plates of mica are continuous and folded round the felspar masses, but little quartz is present.

Smaller bands of fine-grained pink gneiss composed of quartz and orthoclase with small quantities of mica, are associated with the above, while the whole are penetrated by large veins of pegmatite.

For a mile beyond this to the eastward, the railway skirts along the base of the hills on the north, and several cuttings show dark grey fine-grained mica-gneiss, more or less quartzose, interbanded with narrow pink and grey bands of medium texture.

Beyond the outlet of Lake Sargent to Lake St. Joseph, numerous cuttings along the railway show black schistose mica-gneiss, associated with narrow banded, pink and grey, medium-grained orthoclase-mica-gneiss.

These rocks have a dip to the east of north at angles of from 10° to 40° . Pegmatite veins are common and often of large size. Three small veins, seen in the first cutting west of the road from Ste. Catherine to Lake Sargent, contain considerable quantities of magnetite scattered through them in small grains.

The above rocks, embraced in the Deschambault spur, vary considerably as to the local direction of their strike, but on the whole seem to pass down from the Ste. Anne River directly southward to within a couple of miles of their southern limit and then sweep round to the direction of N. 35° W. as far as the end of the spur.

The valley of the Jacques Cartier River above Ste. Jeanne de Neuville, like that of the Ste. Anne, is filled with thick deposits of sand and clay,

which cover all the underlying rocks, and no exposures are seen on its west side until the railway line near Lake St. Joseph is reached.

Division III.

In the bed of the river, for three miles above the Cambro-Silurian Jacques Cartier River. contact, an almost continuous exposure occurs, but as the strike is southerly and consequently at an acute angle to the course of the river, only a small cross section is afforded. The rocks are all a dark grey hornblende-mica-gneiss, varying in texture from fine to medium-coarse grained. Some of the bands are rich in dark red garnet. Numerous large veins of pegmatite cross the rock. Some of them carry small quantities of haematite.

Rocks similar to these are seen along the shores of Lake St. Joseph Lake St. Joseph. and are evidently their northern extension. On the hills north of the railway track, between Lake St. Joseph and Ste. Catherine stations, they are associated with thin bands of alternate pink and grey mica-gneiss. The bands are all highly contorted on the strike, and in places shattered into angular blocks, the joints being filled with pegmatite.

Division IV.

These rocks are followed to the eastward by fine and medium-grained red gneiss, with fine-grained red and grey, narrow banded gneiss; the former being seen at the falls of the Jacques Cartier, one mile Jacques Cartier River. and a half above Ste. Catherine church, where the rock is contorted along the strike and dip, which latter changes from 15° to 45° .

Midway on the road between Ste. Catherine and St. Gabriel stations, on the north side of the railway, outcrops of fine-grained grey and pink gneiss occur. Exposures of similar rocks are seen on the road following the Rivière aux Pins from Lake St. Joseph, and in a small cutting on the railway, where the red variety predominates.

To the south of the Jacques Cartier River, these rocks, associated with a few bands of coarser texture, and penetrated by large pegmatite veins, outcrop along the road running south from Ste. Catherine church and for one mile on the road between the fourth and fifth ranges of Fossambault.

One of the bands along this road is very felspathic and weathers white on the surface, forming a pleasing setting to the quantities of small light pink garnets it contains. At the railway bridge over the Jacques Cartier River at St. Gabriel, the rock is slightly coarser and contains some hornblende with the mica; while one mile south of

the bridge, on the road along the east side of the river, a quarry of red medium to coarse-grained syenitic gneiss has been worked and the stone taken out used for bridge piers for the railway.

As far south as the third range of Fossambault, the general strike is about S. 10° W., but on crossing the west end of the Bonhomme Mountain it bends around to the west with a general direction of S. 65° W., and holds this course until the gneiss passes under the Cambro-Silurian rocks.

Bonhomme Mountain.

On the south side of the Bonhomme Mountain, in the Pointe aux Trembles spur, after the change in the direction of the strike above noted, a number of bands of dark grey mica-gneiss appear with an aggregate breadth of 2,000 yards. These rocks are associated with narrow bands of pink gneiss, generally coarse in texture.

There are no exposures of gneiss on the south and east sides of the Bonhomme Mountain, and the next section across the strike to the eastward is seen, to the north, on the road from Valcartier bridge, up the west side of the Jacques Cartier River, and thence over the mountain to the Rivière aux Pins. Here, for a distance of four miles, an almost continuous exposure is seen, the rocks being fine banded red and light grey, fine-grained orthoclase-mica-gneiss, with more or less quartz, often holding lenticular segregations of mica-schist, and interfoliated with a few narrow bands of coarser grained pink mica-gneiss. The general strike is S. 15° E.

Division V.

Basic granite.

Along the road, on the east side of the Jacques Cartier River, where the road bends north behind Valcartier village, similar rocks outcrop on a small hill, and again where the road crosses the St. Ignace line, they are found in contact with a dark brownish-green compact basic rock. This rock, examined microscopically by Mr. Ferrier*, is found to be a hornblende granitic gneiss, made up chiefly of orthoclase, quartz, plagioclase, hornblende, a rhombic pyroxene and biotite, with magnetite, zircon, apatite and pleonaste. It owes its brownish-green colour to the decomposition of the pyroxene, and shows that it has been subject to great pressure. It occurs in the field as a triangular mass, extending like a wedge from the northern limit of the map, southward on the east side of the Jacques Cartier River, and terminating in a point about two miles north-east of Valcartier village. In places it shows distinct lines of foliation, probably caused by pressure, while in other parts it has a granitic structure, and appears to have been a

Extent of area.

*See Appendix, p. 74 L.

basic granite irrigated along a line of weakness between the fine-grained, fine-banded, grey and pink gneisses to the westward, and the coarse-grained augen-gneiss on the other side. Similar rocks in similar positions are met with in the country immediately north of the area under consideration, and as far as seen, this basic granite always, when present, comes in between the fine-grained gneiss and the coarse granitic augen-gneiss.

In the present case the crushing of the rock has not been accounted for, but must have taken place, subsequent to the injection of the mass and may be due to the great pressure acting on the mass during and after the period of solidification, as the rock does not seem to have been erupted, but rather forced into place or irrigated far below the surface. Along the contact with the fine banded schists portions of these rocks appear to have been broken off and partly floated into the granite, causing them to look as if interfoliated. The contact with the augen-gneiss is concealed, and consequently the relation between the rocks on that side are unknown.

Division VI.

Following this wedge mass of granite, as before stated, comes a mass of augen-gneiss. This rock varies in colour from dark red through dark yellow to pink and grey, the colour depending on that of the orthoclase which forms the greater part of the mass. On the surface this rock is generally greatly decomposed, and then is of a yellow colour. There is nearly always evidence of structure, the large orthoclase crystals being arranged with their longer axis in parallel lines, which correspond to the lines of foliation, although in some places no such lines of foliation appear, and the rock then has a true granitic structure. This rock and the other similar masses appear to be of the same origin, and are likely the lowest members of the Archæan complex met with in this region, as from the limited study made of them, they now appear as bosses, around and over which the fine-banded gneisses have been laid down, while their structure is such as would lead to the belief that they are of igneous origin, and were formed at a considerable depth below the surface, by a slow cooling of the magma probably subsequent to the deposition of the fine grained fine-banded gneisses which have the appearance of clastic rocks, although their high state of crystallization leaves little or no trace of such origin.

The structure shown by these rocks can be accounted for wholly by pressure, and is not due to anything like stratification. The rock macroscopically consists largely of orthoclase, generally arranged in lines of crystals, greatly rounded and lenticular in shape, around these

masses of orthoclase continuous bands of mica, and at times hornblende, fold. Quartz is also always present, but seldom abundantly.

Distribution. This mass of rock is seen on each side of the Jacques Cartier River, in the seventh range of Stoneham, near the limit of the map, where the strike of the foliation is directly south. They are seen again on the road from the river to Stoneham village in the sixth, fifth and fourth ranges, and from there pass southward, crossing the road between Valcartier and Lorette at the bridge over the Nelson River, and then form the high isolated hill east of Valcartier station. Farther southward along the strike they are covered by thick deposits of drift, to where they pass under the Cambro-Silurian shales near St. Ambroise.

Division VII.

Fine banded gneisses. Proceeding eastward across the strike, the next six miles is occupied by fine-banded pink and grey mica-gneisses, which appear to occupy a trough between the last boss of augen-gneiss and a similar boss to the eastward.

Interbanded with these fine-grained rocks are thin layers having a coarser texture, and also bands in which black hornblende replaces the mica, but these are few and relatively insignificant. Many of the grey and pink bands hold quantities of small dark red garnets.

Distribution. These rocks are seen along the road from Stoneham in the first, second and third ranges; also along the road through Tewkesbury, where they are three miles wide. Southward from Stoneham they outcrop along the roads leading to Lorette and Charlesbourg, and extend to the east side of Lake Beauport with a breadth of six miles which is maintained until they pass under the Cambro-Silurian rocks near Lorette and eastward.

At the junction of the road from Charlesbourg with that following the Jaune River to Lake Beauport, is an exposure of graphic gneiss, composed of parallel bands of dark brownish translucent quartz and red orthoclase. The quartz is in the form of flat plates varying from one-eighth to one-third of an inch in thickness, no visible mica or hornblende is present and the rock is stained dark red with splotches of peroxide of iron. A similar band, probably a continuation of the one above, is seen half a mile in rear of Lorette village, on the road along the east line of St. Ignace.

Division VIII.

The next large area of augen-gneiss occupies the country between these fine-banded gneisses and the Montmorency River, in the north-

ern part of the area. These rocks are seen along the road leading from Tewkesbury to St. Adolphe, after crossing the east line of the township; to the south they occur on the lower road leading from Lake Beauport to the Montmorency River, and along the road up the west side of that stream. The southern extension cannot be traced further owing to the deep deposits of till and stratified sands, with which they are covered to beyond the edge of the Cambro-Silurian limestones.

Where foliated, these rocks have a general strike N. 10° W., and like those previously described have usually a rusty-yellow colour on the surface, and are often highly decomposed to a depth of three or four inches. Unlike the Stoneham area, lines of foliation from pressure are here unfrequent, and the mass as a whole resembles a very coarse-grained granite, in some parts of which hornblende takes the place of mica.

Divisions IX. and XI.

The Montmorency River appears to be on or near the eastern boundary, as the rock in the bed of the river above the falls is of the ordinary fine-banded red and grey varieties, while on a traverse line across the mountains from the Montmorency to the Sault à la Puce River, near the northern limit of the map, nothing but angular blocks of fine-grained yellow-weathering hornblende-mica-gneiss was met with, before reaching the anorthosite area on the latter river. Fine banded gneiss.

Eastward of the Montmorency River, the fine-banded gneisses again appear, but they are of a more basic character than those previously described, being composed chiefly of orthoclase, plagioclase, mica, ilmenite and quartz, and generally of a light grey or pink colour-weathering a light yellow. Between the anorthosite area of Château Richer and the Cambro-Silurian outerop, these fine-banded rocks are again seen, with a breadth from one to three miles across the strike, which is nearly N. 50° E. The bands furthest from the anorthosite appear to hold normal quantities of quartz, mica and orthoclase, and closely resemble those before described; but as the anorthosite is approached they are found to be interfoliated with darker coloured, more basic bands, holding large quantities of green pyroxene. These, on further study, may prove to be somewhat of the same character as those of the crushed granite area of the Jacques Cartier River.

A band of crystalline limestone occurs in these rocks and extends from the road in rear of Château Richer to beyond the road running from Ste. Anne church. This limestone is highly crystalline and generally flesh-red in colour, but varies through pink to greenish-white with frequent grains and masses of dark green pyroxene scattered through it. Crystalline limestone.

Gradual
change into
anorthosite.

Between the limestone and the anorthosite the gneiss becomes more and more basic as the latter is approached, until near the contact it is a mica-diorite-gneiss composed almost wholly of plagioclase. The bivalves originally present have been so decomposed that it is impossible to state what they were. A small amount of biotite remains, with large proportions of ilmenite.* From the character of this rock, it is difficult to define the exact junction of the anorthosite, as there appears to have been some action subsequent to the injection of the anorthosite, by means of which much basic felspar and iron materials were removed from the igneous rocks and transferred to the surrounding gneisses rendering them closely similar in composition. In places along the contact these gneisses have a cataclastic structure, probably produced by the pressure due to the injection of the anorthosite mass, but this structure is not constant, as other specimens fail to show evidence of such crushing, and in these cases the anorthosite would appear to have eaten away and replaced the surrounding rocks, which would account for the want of any marked division between the two series.

Division X.

Anorthosite.

Boundaries of
area.

Composition.

The anorthosite mass extends from about two miles from the Montmorency River eastward, roughly parallel to the shore line of the St. Lawrence, and is crossed by the road in rear of Château Richer two miles inland. Its southern boundary appears to closely follow the strike of the enclosing gneisses, which is nearly N. 50° E. It is seen at about the same distance from the St. Lawrence on the road back from Ste. Anne where it passes behind Mount Ste. Anne and leaves the map. The breadth of the area is nearly two miles on the road up the north-east branch of the Sault à la Puce River and is somewhat greater on the road up the north-west branch, while to the eastward it does not exceed that breadth within the limits of the map. These boundaries are only approximate, as the greater part of the area is covered with a thick forest, which renders the tracing of the boundaries difficult and uncertain. The greater part of the rocks is made up of a fine granular greyish-green to greenish-purple triclinic felspar, holding cleavable masses of reddish-purple felspar, the cleavage faces varying from one-tenth of an inch to several inches in diameter.

Hypersthene and ilmenite are common constituents of the rock, and occur in flattened irregular masses, generally arranged in a more or less banded structure, which corresponds with the direction of the foliation

* See Microscopic Examinations by Mr. Ferrier. Appendix.

of the surrounding gneisses. These vary in size from small particles to masses one inch thick by several inches broad.

Specimens of the granular rock were examined*, and were found to Microscopic consist largely of plagioclase and diallage with some biotite and examinations. ilmenite. What was probably originally diallage is now almost entirely changed into serpentine, although here and there a minute unaltered portion may be detected, and much of the material shows good crystal outlines. Some biotite is present associated with the serpentinous decomposition product, and the ilmenite is accompanied by a considerable amount of leucoxene. No traces of hypersthene were noticed and that mineral seems to have been wholly segregated out of the general mass of the rock into the bands and patches before mentioned.

Dr. T. Sterry Hunt made a close study of the rocks from this locality, and the following is taken from his report :—†

"In this region there occur several varieties of the rock, but the most interesting is one made up of a fine granular base, greenish or greyish-white in colour, holding masses of a reddish cleavable felspar, which are sometimes from one-tenth to one-half an inch in diameter, but often take the form of large imperfect crystals, frequently twelve inches long and four or five inches wide. These dimensions correspond to the faces M and T, while the face P, characterized by its perfect cleavage, is from half an inch to two inches broad. Twin crystals sometimes occur, having a composition parallel to M. Hypersthene is met with throughout the rock in flattened masses, which, although variable and irregular in their distribution, exhibit a general parallelism; they are occasionally four or five inches in breadth, by an inch or more in thickness, and are separated from the granular felspathic rock by a thin film of brownish-black mica. Titaniferous iron ore is also found in the rock in grains and lenticular masses, occasionally an inch or two in thickness; these occur in the granular base and generally near the hypersthene, but grains of ore are occasionally found in the crystalline felspar. Quartz in small grains is imbedded in the titaniferous iron ore, but was not observed elsewhere in the rock, nor have any other minerals than these been detected. In the specimens of the rock which I selected on the spot for examination, the crystalline felspar constitutes from one-half to seven-eighths, while the hypersthene does not equal more than two-hundredths, and the titaniferous iron more than one-hundredth of the mass. The amounts of quartz and mica are insignificant. In other portions of the rock, however, the

Examination
by Dr. T.
Sterry Hunt.

* See Appendix.

† Report of Progress Geological Survey of Canada, 1854, page 375.

proportion of the ore may equal five-hundredths, and in some parts the amount of the hypersthene is nearly as great. By the action of the weather the surface of the rock becomes of a dull opaque white ; the cleavable masses of felspar are, however, less affected than the granular portion, and by their obscure reddish colour are distinctly visible on the weathered surfaces ; this change extends but a little distance into the rock. The colour of the iron ore of course remains unaltered, but the dark brown hypersthene becomes lighter, and inclines to pinchbeck brown. This felspar is triclinic in cleavage ; the angle of P:M = 80° 30' ; cleavage with P, perfect ; with the other planes distinct ; P is often delicately striated, and sometimes curved ; hardness, 6·0 ; and density, 2·667 to 2·674. Lustre vitreous, sometimes pearly on P ; colour flesh-red passing into reddish, greenish and greyish-brown ; the surfaces are sometimes clouded with these different tints, but the red predominates. The following analyses are made of three different specimens, which were carefully selected, pulverized, and then dried at 212° F. The earthy ingredients were determined after fusion with carbonate of soda, and the alkalies by the method of Dr. J. Lawrence Smith, which consists in igniting for thirty minutes the finely levigated mineral with five or six parts of carbonate of lime, and three-fourths its own weight of sal-ammoniac. The agglutinated mass slakes by the action of water, and yields to that liquid its alkalies in the form of chlorides, mixed with chloride of calcium. A second ignition of the undissolved residue with two-thirds of the first amount of sal-ammoniac, ensures the separation of the last portions of alkali. These processes were adopted in all the analyses of felspars here given :—

Analyses of
felspars.

	I.	II.	III.
Silica	59·55	59·85	59·80
Alumina	25·62	25·55	25·39
Peroxide of iron.....	·75	·65	·60
Lime	7·73	6·94	7·78
Magnesia	Traces.	·11	·11
Potash	·96	·96	1·00
Soda	5·09	5·09	5·14
Loss by ignition	·45	·30	·00
	100·15	99·45	99·82

"In a fourth specimen the quantity of lime was found equal to 7·89 per cent. The composition of this felspar is very nearly that of andesine, which according to Abich, consists of silica, 59·60 ; alumina, 24·18 ; peroxide of iron, 1·58 ; lime, 5·77 ; magnesia, 1·08 ; potash, 1·08 ; soda, 6·53, 99·92. The greenish base of this rock is in general

finely granular, and strongly coherent ; the grains possess the cleavage, lustre and hardness of felspar, and the density of carefully chosen fragments, was from 2·665 to 2·668. The greenish white of the powder is changed to fawn colour by ignition. When pulverized and digested with acetic acid, the mineral loses two or three thousandths of carbonate of lime, with traces of magnesia, alumina and oxide of iron. A portion which had been thus treated and carefully dried, gave the following results :—

	IV.
Silica	58·50
Alumina	25·80
Peroxide of iron	1·00
Lime	8·06
Magnesia	0·20
Potash	1·16
Soda	5·45
Loss by ignition	0·40
	<hr/>
	100·57

"It is therefore a felspar, differing but little from the crystalline andesine in its composition.

"The hypersthene occurs in foliated masses with curved surfaces. Besides the basal cleavage thus exhibited, it cleaves readily with the sides and longer diagonal of an oblique prism of 87°. The hardness of the mineral is 6·0, and its density from 3·409 to 3·417. Lustre vitreous, submetallic ; colour blackish-brown, in thin laminæ yellowish-brown ; streak and powder ash-grey, the powder turning reddish-grey on ignition. Sub-translucent, brittle ; fracture, uneven. The fragments which had served to determine the density, still contained between their laminæ flakes of felspathic matter, which were as far as possible removed in breaking up the hypersthene for analysis. The results of two analyses by fusion with carbonate of soda were as follows :—

	V.	VI.
Silica	51·85	51·35
Alumina	3·90	3·70
Peroxide of iron	20·20	20·56
Lime	1·60	1·68
Magnesia	21·91	22·59
Manganese	traces.	traces.
Loss on ignition	0·20	0·10
	<hr/>	<hr/>
	99·66	99·98

"It is almost identical in composition with the hypersthene from Labrador, analysed by Damour.

"The accompanying ilmenite was more or less interpenetrated with felspar and quartz, which could not easily be separated. Its hardness was 6·0 and the density of selected fragments from 4·65 to 4·68. Colour and streak iron-black; lustre sub-metallic; not attracted by the magnet. When decomposed by fusion with bisulphate of potash it gave:—

	VII.
Titanic acid	39·86
Peroxide of iron	56·64
Magnesia	1·44
Insoluble, quartz, &c	4·90
	<hr/>
	102·84

"A large portion of the iron is to be regarded as existing in the form of protoxide.

"Another variety of felspar rock from Château Richer is pale greenish or bluish-grey, with occasional reddish grains, and is finely granular. The lustre is vitreous upon the cleavages but waxy elsewhere. The only foreign mineral in the rock was brownish-black mica in small scattered patches. The density of the greenish-grey portion was 2·681, and its analysis gave as follows:—

	VIII.
Silica	55·80
Alumina	26·90
Peroxide of iron	1·53
Lime	9·01
Magnesia	·27
Potash	·86
Soda	4·77
Loss on ignition	·45
	<hr/>
	99·59

To this last variety belong the specimens cut for microscopic examination.

CAMBRO-SILURIAN.

Resting immediately on the Archaean rocks in the southern portion of the area under consideration are beds of Trenton limestone and Utica shale, without the intervention of the older Cambro-Silurian and

Cambrian beds met with farther to the westward, or of the rocks of Quebec City, which, in part at least on palaeontological evidence, alone are by some supposed to be below the Trenton. The absence of these formations is probably due to the deposition of the Trenton and Utica in deeper water at a higher relative level than the earlier formations, causing an overlap of deposition which brings the newer rocks in direct contact with the gneisses on which they, of course, rest unconformably. The Quebec and Lévis rocks, from their lithological character, appear to have been deposited in shallow muddy water with the Archæan area at a considerably higher level than during Trenton time. Their fossils also show, from their diminutive size, that the water inhabited by them was probably very cold, so that at the time of deposition of these rocks, there was an elevation of the Archæan mass with cold water about the foot of its eastern face, conditions favourable to a period of glaciation. The surface of the Archæan rocks on which these newer beds were laid down had a rounded undulating form closely resembling the present exposed surface. The amount of denudation subsequent to the time of deposition of the Trenton does not seem to have been very great in depth on gneisses, as the portions overlaid by the Trenton have almost exactly the same appearance as those exposed during the last glacial period. The gneisses when the limestone is removed, present fresh surfaces and are not decomposed or disintegrated to any appreciable depth, showing that at the time of deposition of the Trenton rocks, either no decomposition of the gneisses due to subaerial decay had taken place, or else the decayed parts had been removed to a great extent, either by water currents or ice action.

Contacts between the Trenton and the gneisses showing these characters are seen at Deschambault Station, on the Jacques Cartier River immediately above the Canadian Pacific railway bridge, at Jeune Lorette along the foot of the Archæan hills, above the falls of the Montmorency, and along the Sault à la Puce and Ste. Anne de Beaupré rivers.

The Trenton limestones appear to have been laid down at the close of a period of subsidence accompanied by an amelioration of climate, as its fossils are normal in size and indicate warmer water, but the finding of a rounded mass of dark red mica gneiss imbedded in the limestone strata some ten feet above the base of the terrane appears to point to floating ice at that time. The above gneiss mass is six feet long, four feet wide and four feet thick, and has been estimated eight tons in weight. It can be seen in the position above described on the west bank of the Jacques Cartier River, fifty yards above the Canadian Pacific railway bridge, and near the present northern limit of the Trenton,

Absence of
older Cambro-
Silurian and
Cambrian
rocks.

Rounded sur-
face of Ar-
chæan rocks.

Contacts be-
tween Trenton
and Archæan.

Boulder in
limestone.

but as the country to the north is almost flat for some miles, the limestones probably extended to the base of the Archæan hills, and have since been largely denuded away. If such is the case, the presence of this large foreign mass cannot be accounted for except that it was dropped there from floating ice, as no ordinary ocean or river current could carry such a large block and deposit it in its present position.

Basal sand rock.

In various places at the contact of the Trenton with the Archæan beds or patches of a calcareous sand rock are seen resting in the hollows of the Archæan surface. These patches vary from a few inches to several feet in thickness, and appear to be formed from detrital material collected in the hollows by water or ice action previous to the deposition of the limestones, and subsequently cemented by calcareous infiltrations.

This sand rock was formerly taken to represent the Potsdam sandstones, but more detailed examination shows it to be of local development, while the upper portions hold fragmental Trenton fossils. Patches of this rock are seen on the Jacques Cartier River, at Lorette on the road where it rises to that village, at the falls of the Montmorency, and on the Ste. Anne de Montmorency River. Beyond the limits of the present report, they are met with on the St. Maurice River, where a thickness of fifty feet is seen, and thence westward are frequently met with where the Trenton comes in contact with the Archæan in eastern Ontario, and also to the east at Bay St. Paul and Murray Bay.

Disturbance and Faulting.

Tangential pressure.

As is well known a great folding, breaking, and faulting of the Cambrian and Cambro-Silurian rocks of eastern Quebec, in common with the other coast rocks of eastern America, occurred in post-Silurian time, and was occasioned by some great tangential pressure, which in the area under consideration acted at right angles to the Archæan mass and consequently from a south-south-east direction.

This force in the more disturbed region twisted the strata into great overfolds and in many places by a series of upthrow faults brought older strata to positions seemingly above newer, and all having been subject to subsequent great denudation their relative age can only be accurately determined by careful palæontological work along with that of the stratigraphy.

Disturbance due to pressure.

The region embraced in this report being near the western limit of the action of this tangential thrust, affords an interesting field to study the difference of intensity of disturbance caused by it. Towards

the western limit of the map, about the valley of the Ste. Anne de la Pérade River, the Cambro-Silurian rocks rest comparatively undisturbed upon the gneisses. Proceeding eastward, evidence of disturbance Variation in is seen in the beds being thrown into low anticlines with the angle of pressure. inclination greater to the south-east, in the direction of the thrust than on the opposite side, while farther eastward the anticlines are sharper and overturn dips appear, followed by prevailing overturns, accompanied by upthrow faults, where in the eastern half of the map the tangential thrust appears to have reached a maximum. In this part the stratigraphy is further complicated by what appears to be a series of downthrow faults along the face of the solid Archæan mass, and formed subsequent to the period of maximum thrust, when owing to relief from pressure, lines of weakness appear to have been developed between the immovable gneisses and the crushed limestones and shales. The spurs of gneiss projecting southward from the main mass which have been before referred to, were important factors in the deformation of the overlying limestones and shales, as it was against and over these spurs that the tangential thrust forced the newer rocks Gneiss buttresses. and formed an anticline on each. These anticlines are sharp towards the south-east with low flowing dips in the opposite direction, and show that the gneisses acted as a buttress and relieved the newer rocks on the west side from the full effect of the thrust, while on the other side the limestones and shales were squeezed up, and over these immovable barriers at times with breaks in the strata caused by upthrust faults.

Passing from west to east the first anticline is that over the Deschambault spur. Here the Trenton limestones fold with flowing dips of 3° to 5° towards the west, where they pass into the low domes of the Ste. Anne valley. On the south-east side the dip is sharper (23°), and the rock is slightly broken on the crest of the anticline, but no evidence of faulting of the limestones or shales is apparent on the next anticline, that over the weakly developed Jacques Cartier spur, where the rocks are in positions corresponding with the Deschambault anticline; the south-east dips being sharper than the north-west ones. Evidence of slight faulting in the shales is seen along the Jacques Cartier River on the east side of the spur, the greatest fault being in the river bed, near the mill, on the small stream which falls into the river on the west side some two miles above its mouth.

At the Pointe aux Trembles spur, the limestones on the west side dip away at low angles until they pass under the shales. On the crest of the anticline they are considerably crumpled and bent into small

Fault.

sharp folds, the folding increasing as the east side is approached and slickensided faces give evidence of faulting among the beds of limestone, culminating in a heavy overthrust fault at the junction of the limestones with the overlying shales. Here the shales are shoved over the limestone, so that they are found in contact with the gneisses along the south-east slope of Bonhomme Mountain to one mile beyond St. Am-broise station, where the limestone again intervenes, and the over-thrust fault apparently dies out, the rocks being again partly protected by the gneiss spur of Montmorency, which probably extends westward beneath the limestone to near Beauport village, and forms the high ground, along the edge of which the Montmorency road passes. Southward from Lorette towards St. Foy, the Loraine shales first form a low syncline and anti-line, followed by a sharper syncline and anti-cline, and then a syncline with overturn dips on its south side, which brings the greyish Loraine shales in contact with the red and green shales of the Sillery on the hillsides, about 200 yards north of Ste. Foy church.

Contact of Loraine and Sillery.

This contact of the Loraine and Sillery shales is brought about by an upthrust fault by which all the measures between the Lower Cambrian and Loraine have been thrown up, and subsequently denuded away, leaving the Sillery rocks in a position apparently conformably above the Loraine.

Champlain Fault.

This fault, as pointed out by Dr. Selwyn,* is met with on the north side of the Island of Orleans where it separates the Lévis and Sillery rocks. From there it passes westward in the bed of the St. Lawrence a short distance in front of the city of Quebec, and reaches the north shore at Wolfe's Cove, about one mile north of Point Pizeau, whence it crosses to Ste. Foy as above described, and here turning south-west comes out again on the north shore two miles above Cap Rouge, where it crosses to the south shore and is seen in the cliffs two miles south of the mouth of the River Rouet, and not far from St. Nicholas church. Thence it extends south-west in the direction of Lake Champlain to Missisquoi Bay.†

Section from Charlesbourg to Quebec city.

A section southward from Charlesbourg, passing through Quebec near the Martello towers on the Plains of Abraham, shows the thickness of the Trenton limestone between the gneiss and the Utica black shales to be much greater than at Lorette. The limestone is seen along the Lake Beauport road for seven hundred yards behind Charlesbourg church, which is situated near the summit of the limestones. The limit between the Trenton and Utica cannot be closely defined here as

* Report of Progress, 1869.

† See R. W. Ells, Annual Report, 1887-88, p. 45 K.

the limestones gradually become stratified with shale beds, which increase in thickness until shale predominates over limestone, and the latter finally dies out in a few thin beds well up in the shale series.

To the north of Charlesbourg church, on the Archæan plateau, the limestone is almost undisturbed and dips towards the south at angles of 3° to 5° , but as the edge of the hill is approached the dips become Change of dip. greater, and immediately behind the church the angle is 38° . Seven hundred yards south of the church and near the bottom of the hill, close to the junction of the black and upper grey shales, the beds are disturbed with dips varying from 43° to 80° , with an average of 50° . This variation in dip points to some small unseen fault, perhaps a continuation of the Montmorency downthrow fault, mentioned later on.

From the foot of the Charlesbourg hill to beyond the St. Charles River, the ground is almost flat, and no rock exposures are seen, but as exposures of greyish-green arenaceous shales, holding Loraine fossils, are met with on either side of the river, it may safely be taken that they occupy the interval between the foot of Charlesbourg hill and the north escarpment of the city, where they are again seen in contact with the Quebec city rocks. Near this contact both formations are broken and crumpled, evidence of a fault along the bedding plane, which brings the beds of Quebec rocks into a position apparently conformably above the shales, but the fossils from the former are held by Mr. Ami to indicate a position below the Trenton*, while the underlying grey shales are undoubtedly at the summit of the Trenton group, their contact north of the city must be an upthrust fault which has lifted out the intermediate strata.

Contact of
Lorraine with
Quebec city
rocks.

This fault is apparently a branch of the great Champlain fault. It Direction of seems to leave the latter a short distance east of the road running north fault. from Ste. Foy church and, passing eastward along the face of the northern escarpment of the city, runs under the St. Lawrence. According to Dr. Ells, the same or a similar fault separates the Loraine from the Quebec city rocks, on the north side of the Island of Orleans, one mile and a half from its west end; a short distance beyond, it again joins the main fault between the Sillery and Loraine rocks.†

On the Montmorency spur of the Archæan rocks, and its apparent extension to the back of Beauport church, the limestones rest almost horizontally and undisturbed with dips varying from 3° to 5° towards the south.

*Prof. Lapworth, Trans. Royal Soc. of Canada, 1886, also Annual Report, 1887-88, p. 46-48 K., H. M. Ami, Bulletin Geo. Soc. of Am., vol. 2.

†Annual Report, 1887-88, p. 71 K.

On the eastern flank of the spur, folding and faulting of the shales have taken place, as on that face of the other anticlines. Added to these disturbances of the strata, downthrow faults now farther complicate the stratigraphy. The section along the Montmorency River shows the limestones resting on the gneiss above the fall to be almost undisturbed, with patches of the arkose sandrock in hollows of the gneiss between the latter and the limestone. The fossils in the limestones show that they belong to the lowest beds of the Trenton, and are overlain by newer beds as the stream is ascended. Near the brink of the cliff at the fall, the beds curve over the edge, while on the west side of the river they are traversed by small crest faults. To the west of the fall along the lower face of the cliff, patches of the arkose sandrock are seen, while on the face of the cliff only a thin band of limestone lies between the gneiss and the Utica shales. The patches of sandrock on the face of the cliff must have been placed there during the period of pressure and folding, when the Trenton must have been bent out of the horizontal and flattened against the almost vertical cliff, with the sandrock below it; and this is now the only record of such a folded and vertical position of these strata against the cliff, the rest of the beds having been let down by a subsequent downthrow fault along the line of weakness between the immovable gneiss and the compressed limestones and shales. This slip must have occurred on the relief from the great thrust pressure which folded up the rocks. The throw of the fault is not less than 500 feet; the difference of level between the top and bottom of the fall is 250 feet, and at least a like thickness can be allowed here for the limestone between the top and bottom of the Trenton. Between the foot of the fall and the mouth of the river are indications of another downthrow fault in the Utica shales, which gives a repetition of the beds of that formation.

To the westward of the fall the course of the downthrow is easily traced to near Beauport church, as it runs parallel to and at a short distance from the main road from Beauport to Montmorency; for the greater part of this distance the road passes over bare ledges of flat limestone, while close to it, on the south side, the shales are seen tilted up at a high angle.

West of Beauport the ground is flat and drift-covered, concealing any evidence of the south-west extension of the Montmorency fault. Near this point the flat-lying Trenton limestones are cut off and thrown to the north, by a transverse dislocation, together with the overlying shales. At Parent's quarry a quarter of a mile from the mouth of the Beauport River there is a very

Downthrow
faults.

Throw of
fault.

apparent dislocation of the limestones ; the shales as they continue to the westward maintain a high angle of dip on the west side of the dislocation, a new condition, not apparently caused by the thrust action but by a transverse downthrow fault.

To the eastward of Montmorency it is very difficult to trace the limits of the downthrow fault, as the beds are here folded up and faulted by the thrust, rendering it impossible to tell, from the denuded patches near the contact with the gneiss, whether the beds have been shoved up or let down.

The thin tilted beds of limestone and overlying shale cross the main road half a mile beyond the Montmorency bridge, immediately to the north of which the gneiss rises from beneath them. The limestone outcrop between the gneiss and shales is very narrow and the dips are high until the Château Richer spur is approached, where on the protected west side and top of the anticline the dips are lower, and the limestone outcrop broader. On the south-east side of the spur the rocks are in a condition similar to those at Montmorency, having first been folded up and then let down by a fault, so that at the fall of the Sault à la Puce River, where the water drops sixty feet over the face of the gneiss, above the fall are beds of limestone and sandrock patches, while below are seen the arenaceous shales of the Loraine. These shales continue in contact with the gneiss for two miles to the north-eastward, when the fault apparently dies out, and a thin strip of Trenton is interposed and continued to the River à la Rose.

The dip is at a high angle, but diminishes as the Ste. Anne spur is approached where the limestone again spreads out over the top of the Ste. Anne anticline.

On the south-east side at the foot of the lowest cascade of the Ste-Anne River the limestones are seen to dip south at angles varying from 30° to 70° and are followed conformably by black Utica and grey shales.

The Trenton and Utica are also seen on the east side of this anticline along the road from St. Joachim to Bay St. Paul, and on the Friponne River where it descends from the gneiss, in both localities the limestone resting on the gneiss dips nearly south, at an angle of 30°.

Distribution of the Trenton.

Westward of the Deschambault anticline to the limits of the sheet, is a large development of limestone. On the Ste. Anne de la Pérade River they are first seen at the Three Rapids, half a mile in a straight line south from the last exposure of gneiss, the intermediate rocks being covered by stratified clays. The dip is S. 80° W. <7°, and the beds have a transverse measurement of 650 yards, giving a thickness

West of
Deschambault
anticline.

of 250 feet. The beds here are thin ; the lower ones hold considerable quantities of cherty nodules, with an occasional band of the same mineral, and also some small crystals of blende.

The fossils also are silicified and weather out in a beautiful manner ; the following fossils found here place the beds in the Trenton :

Prasopora lycoperdon, Vanuxem.

Lingula, sp.

Orthis testudinaria, Dalman.

Leptaena sericea, Sowerby.

Strophomena alternata, Conrad.

Rhynchonella increbescens, Hall.

Platystrophia biforata, var. *lynx*, Eichwald.

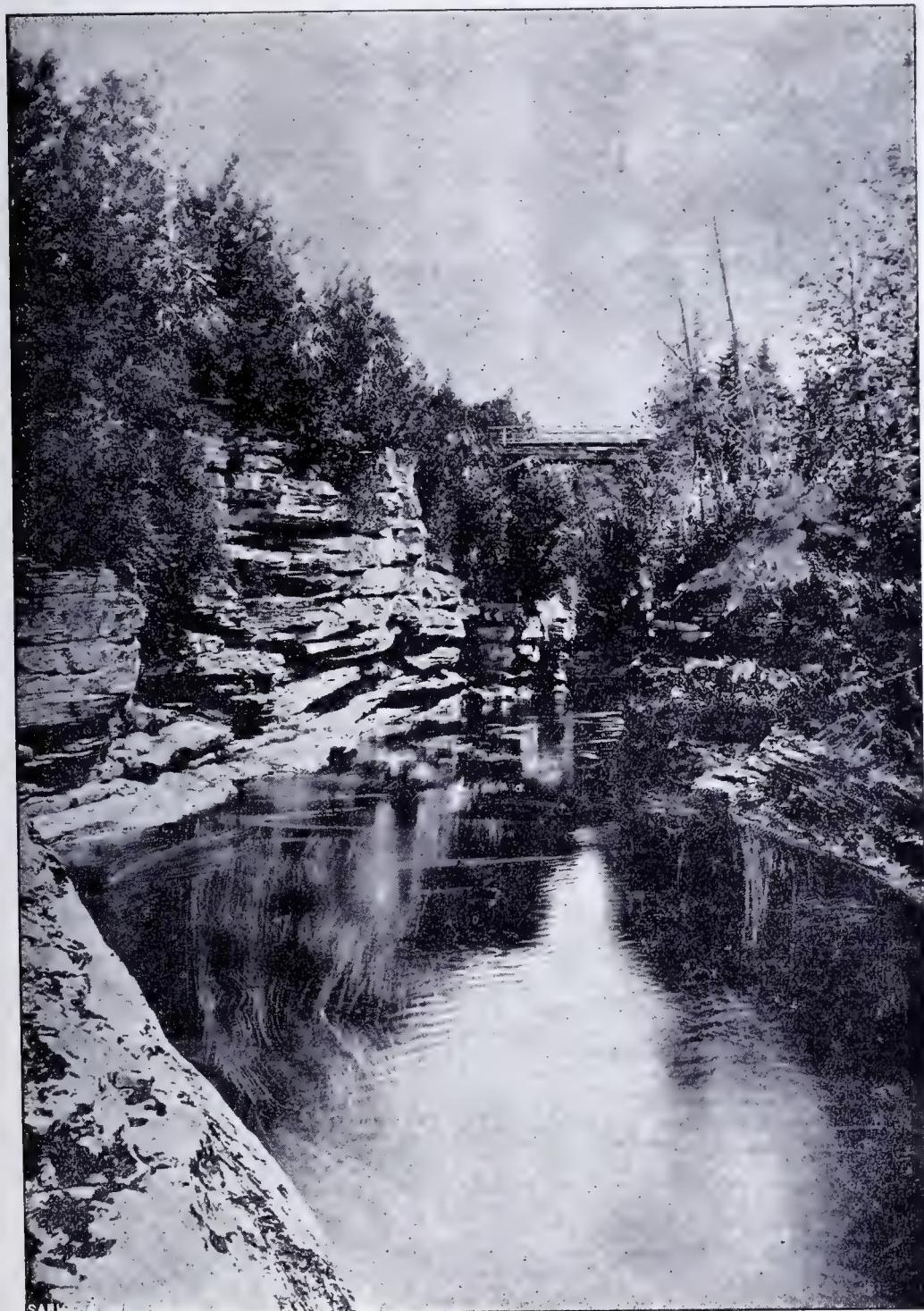
Orthoceras, sp.

Three miles further down stream and one mile and a half from the gneiss, similar limestone, with silicified fossils, is seen at the Cascades, and from there past the village of St. Alban to beyond the limit of the map, the river passes through a narrow gorge in the limestone, with vertical walls from twenty to sixty feet high. The limestone is only disturbed by low undulations, and the entire section exposed does not exceed 300 feet. Among the fossils collected at and below St. Alban bridge are : *Stictopora acuta*, Hall; *Prasopora lycoperdon*, Vanuxem; *Lingula quadrata*? Eichwald; *Orthis pectinella*, Conrad; *Strophomena alternata*, Conrad; *Cyrtodonta cephalus*, *Asaphus platycephalus*, Stokes.

Western extension.

From the Ste. Anne River the limestone passes westward to the St. Maurice River, beyond which the rocks are concealed by drift. To the south and east of the Ste. Anne, with the exception of the small triangular area of Utica shale west of Grondines Point, the limestones are abundantly seen on all the roads in the seigniories of East and West Grondines, Tesserie, La Chevrotière and Deschambault, coming out on the St. Lawrence a short distance above the old windmill at Pointe à Maçon. From here to the La Chevrotière River, a distance of four miles, the coast presents a naked and often perpendicular cliff of limestone in slightly inclined strata, in some places over 100 feet above the river.

On all the roads running back from the St. Lawrence in this locality the limestone is constantly seen outercopping from under a thin covering of soil. Further inland, towards the Ste. Anne River, the stratified surface deposits become thicker and the rock exposures fewer, but sufficient are seen to show that no shales occur in this area. Along the road between St. Alban and La Chevrotière station, in the fourth range of La Chevrotière, and the south part of St. Alban parish,



A. P. Low, Photo., 1889.

GORGE IN TRENTON LIMESTONE
AT ST. ALBAN BRIDGE ON THE ST. ANNE DE LA PÉRADE RIVER, P. Q.

extensive quarries are worked where massive beds of limestone outcrop. The beds are few in number, and as they are everywhere near the surface, the excavations are seldom over ten feet deep. From their position these beds would appear to represent the middle Trenton, and hold the following fossils :

Prasopora lycoperdon, Vanuxem.

Strophomena alternata, Conrad.

Orthis testudinaria, Dalman.

Anastrophia hemiplicata, Hall.

Ceraurus pleurexanthemus, Green.

Asaphus platycephalus, Stokes.

From the mouth of the La Chevrotière River, where the limestone passes under the Utica shales, its summit runs north-east and crosses the road and Belisle River about one mile from the St. Lawrence, Belisle River. where it is seen in an old quarry ; the rock here occurs in massive beds and is of a dark grey colour, but the stone is injured by thin patches and beds of black bituminous shale, and is often traversed by small cracks filled with bituminous matter. From here to the second range road and along it to the eastward numerous exposures of limestone are seen dipping at a low angle towards the west.

On the line between the first and second ranges, one quarter of a mile to the west of the road which runs back from the village of Deschambault, and also immediately to the east of the same road, just inside the second range, the limestone is seen folding over the anticline, and in both places dips N. 85° E. $<23^{\circ}-40^{\circ}$. In the first mentioned place the crest of the anticline is seen, with a few cracks and breaks on it, while in the second the beds are broken off against the gneiss, which here rises to a higher level. These beds are massive and granular.

On the east side of the Archæan spur the limestone appears to form only a narrow strip along the base of the hill, between the gneiss and shale, until it again broadens out in the valley of the Portneuf River to the south of St. Basile, where it has a breadth of one mile between the church and the railway station ; and is seen in the river valley, for a short distance on either side of the St. Basile bridge, with a dip S. 30° E. $<2^{\circ}$.

From here the northern edge sweeps round through the parish of Terrebonne, and comes out on the Jacques Cartier River two hundred yards above the Canadian Pacific Railway bridge, while its summit passes south through the parishes of L'Enfant Jésus and Grand Bois, folding over the anticline on the road from Cap Santé to Ste. Jeanne de Neuville near the line between D'Anteuil and Neuville ; and from

there sweeps round to the eastward, crossing the Jacques Cartier River half a mile below the white or middle bridge, and one mile and a half from the lowest exposure on the river.

Jacques
Cartier River.

Like the Ste. Anne River the Jacques Cartier has cut a deep gorge in the limestone, through which it runs with a strong current, especially in the lower part where it passes around a narrow neck, and rushes under the white bridge with a considerable fall. Across this neck is a subterranean channel through which passes a body of water sufficient to drive a mill on the lower side where it pours out of an opening in the vertical cliff.

East of the Jacques Cartier River few exposures of limestone are seen, but its northern boundary appears to follow the Archaean outline along the north side of the road from Ste. Jeanne to the second range of Fossambault, where it turns south and bends around the gneiss at Pointe aux Trembles.

Pointe aux
Trembles.

The summit beds on leaving the Jacques Cartier cross the Rivière aux Pommes near the bridge in the fourth range, and then bend towards the south, crossing the road from Pointe aux Trembles in the middle of the third range, and again near the line between the first and second ranges, and come out on the north bank of the St. Lawrence, seventy-five chains west of Pointe aux Trembles wharf.

From here they occupy the shore line for a distance of 140 chains, where, folding over the anticline, they again pass under the Utica shales. As before stated the section here shows that the limestone on the west side of the anticlinal axis is only slightly disturbed into long folds with dips not exceeding 20°; while on the east side the folds are shorter and the angles higher, ranging up to 40°. Slickensided faces are also common and the beds are somewhat broken, with the shales thrust over them. The following characteristic Trenton fossils from this locality were collected principally by Dr. R. W. Ells and named by Mr. H. M. Ami:—

Heterocrinus Canadensis, Billings.

Leptaena sericea, Sowerby.

Strophomena alternata, Conrad.

Strophomena deltoidea, Conrad.

Anazyga recurvirosta, Hall.

Anastrophia hemiplicata, Hall.

Orthis testudinaria, Dalman.

Modiolopsis, sp.

Dalmanites callicephalus? Green.

Calymene senaria, Conrad.

Calymene, sp.

Asaphus platycephalus, Stokes. (= *Isotelus gigas*, DeKay.)

Ceraurus pleurexanthemus, Green.

From Pointe aux Trembles to St. Ambroise no limestone is seen, the Utica shale resting directly on the gneiss along the south-east flank of the Bonhomme Mountain.

Directly north of the road leading from St. Ambroise station to Lorette, about three-quarters of a mile east of the station, thin beds of Lorette, black bituminous limestone followed by grey beds, all highly slicken-sided, come in between the gneiss and the shale.

The limestone in this position is seen along the face of the Archæan hill to the south of the village of Lorette, where it conforms in dip with the irregular contour of the gneiss bosses. The basal beds of recemented Archæan debris are only represented by one small patch along the road rising to the village.

At the falls of the St. Charles River, dark-coloured limestone is seen St. Charles resting directly on the gneiss, and is followed by lighter coloured grey River. beds, showing in the river section a breadth of seven hundred yards, dipping southward at angles varying from 15° to 30°, and giving a thickness of six hundred feet, when they pass under the shales.

The following is a list of fossils from the limestones at the falls of the St. Charles River, collected by Dr. Ells, L'Abbé Laflamme, and Messrs. Giroux and Ami, and determined by the last-named gentleman :—

Stictopora acuta, Hall.

Batostoma Ottawaense, Foord.

Prasopora lycoperdon, Vanuxem. = *P. Selwyni*, Nicholson.

Discina Pelopea, Billings.

Linigula Philomela, Billings.

Leptæna sericea, Sowerby.

Strophomena alternata, Conrad.

Orthis testudinaria, Dalman.

do sp. indet.

do sp. nov. (?)

Anastrophia hemiplicata, Hall.

Bucania punctifrons, Emmons.

Bellerophon bilobatus, Sowerby.

Conularia Trentonensis, Hall.

Theca, nov. sp.

Ctenodonta dubia, Billings.

Pterinea Trentonensis, Emmons.

Ambonychia orbicularis, Emmons, or n. sp.

Trochoceras Halli, Foord. *Lituites undatus*, Emmons.

- Endoceras proteiforme*, Hall.
Primitia Logani, Jones.
Aparchites mundulus, Jones.
Primitia mundula, J.
 do do var. *incisa*, Jones.
Beyrichia quadrifida, Jones.
Isochilina Whiteavesii, Jones.
 do *Amii*, Jones.
Leperditia (?) obscura, Jones.
Polycope, sp.
Ceraurus pleurexanthemus, Green.
Calymene senaria, Conrad.
Encrinurus vigilans, Hall.
Dalmanites callicephalus, Green.
Trinucleus concentricus, Eatm.
Asaphus platycephalus, Stokes.
Illænus Milleri, Billings.
Lichas, sp.

On the Rivière des Mares the summit of the limestone passes just south of the mill on the Lorette-Charlesbourg road. It then sweeps round the escarpment to Charlesbourg, where it is seen in several small quarries opened for road metal, the stone being divided into small beds by partings of shale, and holding considerable quantities of bituminous matter in cracks and partings in the beds, which render it inferior as a building stone.

Passing immediately north of the Charlesbourg church, the summit continues eastward to the Bourg Royal road, where it bends towards the south as it rises to the Montmorency anticline and crosses the Quebec and Beauport road a little west of Beauport River. Near here is Parent's quarry, in the limestone beds which are extensively worked for building stone. An evident dislocation of the beds occurs here as the dip changes from S. 30° W. $< 28^{\circ}$ on the west side of the quarry to N. 67° W. $< 6^{\circ}$ on the east.

From a collection of fossils made at this locality by Mr. D. N. Saint-Cyr, in 1888, the following have been determined by Mr. Ami:

- Prasopora lycoperdon*, Vanuxem.
Amplexopora discoidea, James.
Lingula obtusa, Hall.
Strophomena deltoideo, Conrad.
Anastrophia hemiplicata, Hall.
Conularia Trentonensis, Hall.
Orthoceras, n. sp.

Asaphus platycephalus, Stokes.

Calymene senaria, Conrad.

Ceraurus pleurexanthemus, Green.

As before stated, from Beauport to the Montmorency River, the summit of the limestone is immediately south of the main road, where the tilted beds of shale are seen overlying it and are brought into position by the downthrow fault.

From the St. Charles River the northern limit of the limestone coincides with the base of the Archæan hills extending north-east, and on the L'Epiphanie road shows a breadth of one mile and a-half. On the Charlesbourg and Lake Beauport road, the northern limit is one mile from the summit of the terrane; and, unlike in most places, presents an escarpment on the north side, with a considerable interval of lower level country between it and the next Archæan rise.

At Templeman's quarry, situated to the east of Lake Beauport Templeman's road, near the edge of the escarpment, the limestone is in thin beds quarry. interstratified with a considerable number of thin bituminous shale beds. The fossils from this quarry, collected by Messrs. Ami and Giroux, represent the following species:—

Pachydictya acuta, Hall.

Ptilodictya falciformis, Nicholson.

Prasopora lycoperdon, Vanuxem.

Crania, sp. (parasite on a large orthocerite).

Schizocrania or *Discina*, sp.

Lingula reciniformis, Hall.

Leptæna sericea, Sowerby.

Stropomena alternata, Conrad.

Orthis testudinaria, Dalman.

Murchisonia gracilis.

Endoceras proteiforme, Hall.

Calymene senaria, Conrad.

Along the Bourg Royal road the breadth is about one mile and a quarter from the shales to the gneiss, the latter contact being covered with drift.

The road running back from Beauport passes for three miles over almost horizontal ledges of limestone with a small dip towards the south; to the eastward as far as the Montmorency River outcrops of limestone are very numerous, especially along the road from Charlesbourg to Laval, where a lime kiln and quarry seem to be a necessary part of the equipment of every farm.

Above the falls of the Montmorency River flat beds of limestone, form the bottom and sides of a gorge through which the river rapidly

In rear of
Beauport.

flows for two miles. These beds extend eastward a short distance until they are cut off by the Archæan spur and the downthrow fault.

The position and relation of the limestone and other strata at and below the Falls of Montmorency have been previously described, and it only remains to add a list of fossils collected from the limestones in this vicinity, these collections were made by Dr. Ells and Messrs. Ami and Giroux, and have been determined by Mr. Ami.

From the left bank of the river, near the bridge above the Falls, the following come :—

- Stictopora acuta*, Hall.
Prasopora lycoperdon, Vanuxem.
Solenopora compacta, Billings.
Lingulaacurta, Hall.
Strophomena alternata, Conrad.
Leptaena sericea, Sowerby.
Orthis testudinaria, Dalman.
Orthis pectinella, Conrad.
Anazyga recurvvisrostra, Hall.
Zygospira modesta, Say.
Conularia Trentonensis, Hall.
Bucania punctifrons, Emmons.
Bellerophon bilobatus, Sowerby.
Murchisonia gracilis, Hall.
Murchisonia perangulata, Hall.
Orthoceras laqueatum, Hall.
Vanuxemia, sp.
Harpes, sp.
Encrinurus vigilans, Hall.
Asaphus platycephalus, Stokes.
Ceraurus pleurexanthemus, Green.
Illaenus Milleri, Billings.

Thin bedded bituminous limestone on the property of Mr. Hall to the West of the Falls gives the following species :—

- Sponge-like organisms.
Lingula, sp. indst.
Orthis testudinaria, Dalman.
Strophomena alternata, Conrad.
Strophomena ? sp.
Conularia, sp. indst.
Trinucleus concentricus, Eaton.

Along the brook, on the east side of the gorge at the foot of the Falls, the following fossils were collected from beds of light grey-weathering,

impure bituminous limestones and overlying black bituminous shale, on the south side of the fault. The fossils from the lowest beds are marked thus (*) :

- * *Hyalostelia*, sp.
- Diplograptus*, sp.
- Climacograptus*.
- Retesgraptus eucharis*, Hall.
- Orthograptus quadrimucronatus*.
- * *Glyptocrinus glyptocystites*, sp.
- Lingula curta*, Hall.
- Leptobolus insignis*, Hall.
- * *Leptaena sericea*, Sowerby.
- * *Strophomena*, sp.
- * *Orthis testudinaria*, Dalman.
- Serpulites dissolutus*, Billings.
- * *Primitia*, sp.
- * *Calymene senaria*, Conrad.
- * *Illaenus*, sp.
- Triarthrus*, Green.

The distribution of the Trenton limestone to the east of Montmorency has already been referred to, in conjunction with the faulting, and it only remains to say that where the limestone folds over the Château Richer anticline, extensive quarries are worked, and excellent building stone is produced.

Lorraine.

Immediately overlying the Trenton limestones are beds of black bituminous shale. These in most places pass imperceptibly upwards into an arenaceous friable grey-green shale. The black shales, from their fossils, are undoubtedly Utica shales, while the latter represent the Hudson River rocks. From the difficulty found in defining their exact line of junction in many of the sections it has been deemed advisable to unite them under the name of Loraine, especially as the black shales nearly everywhere form only a thin band, seldom exceeding one hundred feet in thickness and consequently impossible to map on the scale of the present sheet. These shales are first met with in a small triangular area, to the west of the limestones of the Deschambault anticline, where a few exposures are seen on the low points west of Pointe à Maçon on the St. Lawrence; and they occupy the low ground south of the limestone to the Ste. Anne River.

On the east side of the anticline, the shales are first seen on the river front a short distance east of the mouth of the La Chevrotière

Cap Santé

River, and from there occupy the north shore of the St. Lawrence until again displaced by the limestones of Pointe aux Trembles. From Deschambault to within two miles of Cap Santé the shore line is low with a few exposures of shale resting almost horizontally. Below this the grey shales form a bold cliff as far as the mouth of the Jacques Cartier River. Rising from below these shales at a low angle, are thin beds of a greenish argillaceous limestone about twenty feet thick. The limestone is seen along the base of the cliff until it crosses the anticline and again passes below the shore line, about half way between Cap Santé wharf, and the Jacques Cartier River. Above the main band of limestone and included in the grey shales are some half dozen thin beds of similar stone, which serve admirably for window-sills, hearths, etc. These limestones appear to have been considerably jointed, the planes of division running in three principal directions. On the east side of the anticline the limestones are somewhat folded and dip at a higher angle than to the west where the angle is not above 2° or 3° .

Portneuf
River.

Back from the St. Lawrence the shales are seen resting on the limestone at the first rise near the Belisle River, and from there appear to occupy the low ground between the St. Lawrence and the first step to the Portneuf River, where they come out in its bed about one mile from its mouth, and again on the road near St. Basile station.

Jacques
Cartier River.

From here they sweep southward over the Jacques Cartier anticline, and are seen along the lower three miles of the roads leading from Ste. Jeanne de Neuville to Cap Santé.

The valley of the Jacques Cartier River, below where the summit of the Trenton passes under the shales, affords a good section of the shales, as the river descends rapidly in a narrow channel between almost vertical walls of shale from fifty to one hundred feet high. Along this section of eight miles, the shales are generally seen in long low undulations, but in a few instances they are tilted up and appear to be faulted; one marked fault is seen where a small brook falls in from the west bank near the east line of Jacques Cartier seigniory. Owing to the precipitous sides of the valley, and almost continuous rapids of the river, no detailed examination can be made in this valley.

L'Ecureuil.

In the shore section of the St. Lawrence, east of the Jacques Cartier River, the black and grey shales form the bold vertical cliff of L'Ecureuil, until they give place to the limestones of Pointe aux Trembles. Throughout this distance the beds are arranged in a series of long low anticlines and synclines, with dips never exceeding 8° , and showing only slight local twistings of the strata. Interbedded with the shales are a few thin bands of bituminous limestone, which well mark the undulations on the cliff face.

Inland the beds are more contorted in places and have higher dips.

Numerous exposures are seen along the river road, on that of the second range, and along the road leading to the white bridge over the Jacques Cartier River. These exposures show the northern limits of the shales to extend from the Jacques Cartier eastward through the front of the fourth range, to the road running back from Pointe aux Trembles, which it crosses three miles and a half from the St. Lawrence, and then sweeps round recrossing the road at the second range line and comes out on the St. Lawrence, seventy-five chains west of Pointe aux Trembles wharf.

As before stated, on the east side of the Pointe aux Trembles anticline, the shales have been thrust over the limestone, and are found in contact with the gneiss on the east flank of the Bonhomme Mountain, they rest on the gneiss at angles approaching the vertical and give evidence of overturn dips near the contact in the third range of Des Maures.

On the shore, near the contact with the limestone east of Pointe aux Trembles, the following fossils were collected by Dr. Ells and others:—

Diplograptus, sp.

Orthograptus quadrimucronatus, Hall.

Climacograptus, sp.

Leptobolus insignis, Hall.

Triarthrus Becki, Green.

Along the St. Lawrence the shales are seen on the low points, and in the cliff, from the fault below Pointe aux Trembles, to where they are cut off by the Champlain fault above Cap Rouge. As the contact with the Sillery rocks is approached, the Loraine shales are found to be broken and contorted both in dip and strike, evidence of the disturbing action of the great upthrust fault.

In this shore section the dips vary from 15° to 75° , and are generally towards the south-east.

Inland, on the roads throughout the southern portions of the Inland seigniories of Des Maures, Gaudville and St. Gabriel, exposures of shale are frequently seen overlaid by a stiff clay soil, largely formed from the disintegration of the shales. In these exposures the strike, N. 30° E., is very uniform, with the dip at high angles generally to the southward, but some to the northward of the vertical, giving evidence of sharp folding, and probable repetition of the beds in the section from the gneiss to the Cambrian rocks.

Eastward from St. Ambroise, where the limestone again comes in between the shales and the gneiss, black shales follow the face of the

West of
Pointe aux
Trembles
anticline.

East of
Pointe aux
Trembles
anticline.

Junction with
Sillery above
Cap Rouge.

limestone plateau and are seen along the St. Charles and Des Mares rivers, the quick change in dip from nearly horizontal on the plateau to angles of upwards of 40° on its sides, is the only evidence here of any fault action.

Along the road from Lorette to Charlesbourg *Climacograptus*, sp., *Orthograptus quadrimucronatus*, Hall, and *Leptobolus insignis*, Hall, are common in the black bituminous shales. About one hundred yards Charlesbourg south of the Charlesbourg church, along the main road from Quebec, Mr. Ami collected the following species :—

Climacograptus.

Orthograptus quadrimucronatus, Hall.

Leptograptus flaccidus, Hall.

Leptobolus insignis, Hall.

Strophomena, sp.

Bellerophon bilobatus, Sowerby.

Leperditia, sp.

Triarthrus Becki, Green.

Beauport

Skirting the face of the hill the shales cross the Charlesbourg road ; where the lower beds are interstratified with several thin bands of bituminous limestone. East of this they soon bend to the southward, on the west line of the Seigniory of Beauport, crossing the Quebec and Beauport road, a short distance west of the river, and here resting apparently unconformably on the limestone along the western extension of the Montmorency fault. In the black bituminous shales overlying the limestone at Parent's quarry, the following fossils were collected by Mr. St. Cyr :

Schizocrania filosa, Hall.

Leptaena sericea, Sowerby.

Lyrodesma pulchellum, Emmons.

Endoceras proteiforme, Hall.

Asaphus Canadensis, Chapman. = (*A. latimarginatus*, Hall.)

Diplograptus, sp.

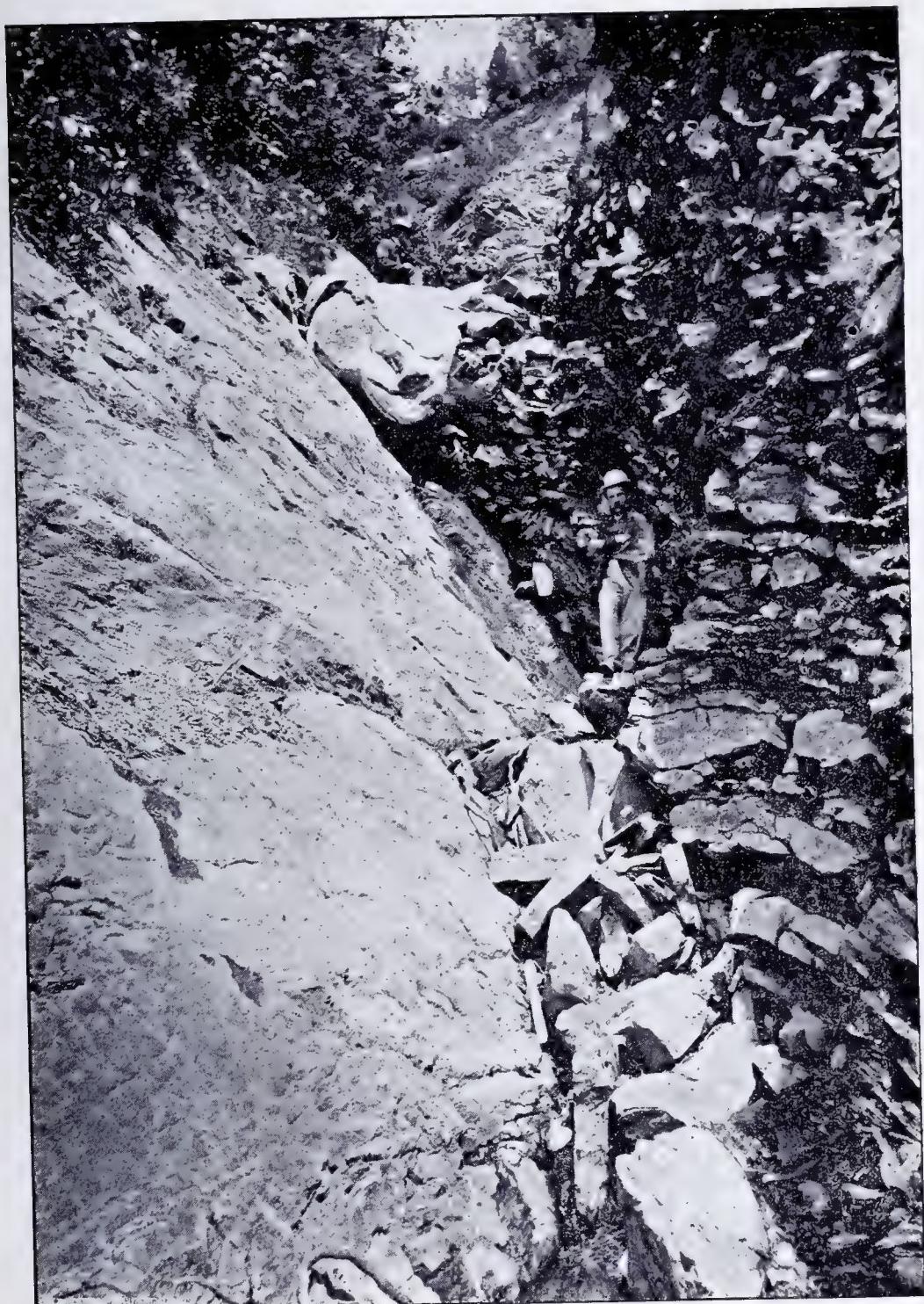
Mont-
morency.

From Beauport to Montmorency Falls the shales occupy the hillside and low ground south of the main road, resting on the flank of the limestone plateau. Below the falls and between them and the mouth of the river, Mr. Ami has collected the fossils below, from the black and grey shales which there conformably overlie the upper Trenton beds tilted up at the base of the cliff :

Climacograptus, sp.

Orthograptus quadrimucronatus, Hall.

Leptobolus insignis, Hall.



From Photograph Presented by Mr. C. D. Walcott, U. S. Geol. Surv., 1889.
FAULT BETWEEN ARCHEAN GNEISS AND TRENTON LIMESTONE AND
UTICA SHALE, JUST SOUTH OF MONTMORENCY FALLS, Q.

Endoceras proteiforme, Hall.

Triarthrus Becki, Green.

Serpulites, sp.

The southern limit of these rocks in the vicinity of Quebec, and their relations to the Quebec City and Sillery rocks, have been referred to previously when tracing out the course of the faults that separate them. To the eastward of the Montmorency River, as before stated, the shales are seen along the shore, and occupy the lower interval between it and the gneiss, except where the limestone intervenes on the crests and western sides of the anticlines.

Along the Ste. Anne de Montmorency River an excellent section of the black bituminous Utica shales, with the overlying grey shales and sandstones, is seen extending from the foot of the lower fall, which is caused by tilted up beds of limestone, on which the shales rest. The section extends down stream to the junction of its tributary, the River à la Rose. This section, carefully measured by Sir Wm. Logan, and published in the Report of 1852-53, and in "The Geology of Canada," 1863, is as follows, in ascending order:

Ste. Anne de
Montmorency
River.

	Ft.
(1) Black, brittle, bituminous shale, with <i>Lingula</i> and <i>Graptolithus</i>	19
Black, brittle, bituminous shale, with two bands of yellow	shales.
weathering limestone, black within	8
Black, brittle, bituminous shale.....	23
Black, brittle, bituminous shale, breaking into small fragments	
in consequence of a cleavage independent of the bedding... .	11
Black, brittle, bituminous shale, with <i>Graptolithus</i>	245
Grey, hard sandstone, interstratified with bands of black shale	5
Black, brittle, bituminous shale, interstratified with beds of	
sandstone	7
	<hr/>
	318

(2) Light grey, yellow weathering sandstone, with black argillaceous nodules at the top ; in some parts the sandstone beds hold fossils, which are obscure, but appear to be <i>Orthis testudinaria</i> and <i>Leptæna sericea</i>	10
Concealed	13
Black, brittle, bituminous shale	6
Dark grey argillo-arenaceous shale	51
Dark grey argillo-arenaceous shale	192
Dark grey argillo-arenaceous shale, with thin beds of sandstone	8

Section of shales.	Ft.
Light grey sandstone in a massive bed, weathering greenish in the air, and reddish in the water ; two bands of conglomerate occur in the middle, holding pebbles of limestone and quartz ; some parts appear to weather faster than others in bands conformable to the bedding	18
Dark grey, slightly greenish argillo-arenaceous shales	58
Light grey, conglomerate bed, with about two feet of fine-grained sandstone at the bottom ; the conglomerate parts hold pebbles of limestone and quartz, of various sizes up to two inches in diameter, those of limestone being in greater abundance than the quartz	5
Grey sandstone, a massive bed becoming of a conglomerate character in parts	14
Grey calcareous conglomerate, as before	3
Light grey sandstone, weathering brownish	3
Grey calcareous conglomerate, with soft shaly sandstone as a matrix	2
Greenish argillo-arenaceous shale, striped with dark grey bands	84
Greenish argillo-arenaceous shale, striped with dark grey, and having a six-inch band of hard, light grey, reddish weathering sandstone at the top, and another at the bottom	18
Greenish argillo-arenaceous shale, striped with dark grey, with occasional bands of hard, light grey sandstone, weathering reddish brown, as before	125
Greenish argillo-arenaceous shale, striped with dark grey, with thinner and finer bands of light grey sandstone	39
Greenish argillo-arenaceous shale, with dark stripes, without any bands of sandstone	70
	719
(3) Black, brittle, bituminous shales, weathering reddish and yellowish brown, and holding <i>Graptolithus ramosus</i> and <i>G. bicornis</i> , with a small <i>Orbicula</i> and <i>Triarthrus Becki</i>	16
Black bituminous and slightly arenaceous shale, not quite so brittle as the preceding, except in a few hard black bands which have <i>Graptolithus</i>	17
Black bituminous and slightly arenaceous shale, with two bands of the harder, more brittle and more bituminous character, the latter with <i>graptolithus</i>	4
Dark grey bituminous and slightly arenaceous shale, finely striped with black lines	33

	Ft.
Black brittle bituminous shale, weathering a light or yellowish-brown, without grit and holding <i>Graptolithus</i> and <i>Orthoceras</i>	7
	<hr/>
	77
	<hr/>
	1,114

"The first division of the above section presents the lithological characteristics of the Utica formation, and the second those of part of the Hudson River. The third so thoroughly resembles the first division that it is very difficult to distinguish them, particularly as there is a resemblance between the two in the few fossils which are met with. An additional amount of dark grey bituminous and arenaceous shales, interstratified with occasional light grey, brown-weathering sandstones, overlies the third division on the Ste. Anne, occupying the distance between the mouth of the Rivière à la Rose and the St. Lawrence."—Geology of Canada, 1863, pp. 199-200.

SUPERFICIAL DEPOSITS.

The entire area under consideration has been subject to extensive ice action, but not to so great a degree as other parts of eastern Canada, more to the northward and westward. This lack of energy in the glacial force may be in part due to the amelioration of climate caused by the proximity of the sea, and in part to the limited extent of southern incline from the high coast range between the St. Lawrence valley and the lower, less mountainous country of the northern interior. This range of highlands has to a considerable extent impeded the movement of the great interior ice cap, and used up a great part of its energy before it reached the St. Lawrence slope; so that, although the entire surface of the high region south of Lake St. John appears to have been glaciated, the evidence of intense ice action is not so marked as in the lower country to the north of that lake. There the deeply denuded and highly grooved surfaces of the gneiss, show that an immense flow of ice passed down from the interior plateau, in a remarkably straight course over all obstructions, in a direction of S. 5° W., with no variation on either side exceeding 10°.

Causes of modified ice action.

This ice flow crossed the valley of Lake St. John, at an elevation of Probable source of ice. three hundred and fifty feet above the sea, and, in part, pushed up over the higher country south of the lake, carrying with it boulders of Trenton limestone, from deposits in that basin, to an elevation of

eleven hundred feet above the position of its present highest bed and to a distance of twenty miles from its present nearest exposure.

It farther probably passed over the summit between the waters of the Saguenay and those of the St. Lawrence, at a general elevation of fifteen hundred feet above sea level, and thence descended to the St. Lawrence.

As the difference in elevation between the valley of Lake St. John and the general level of the southern summit is fully eleven hundred and fifty feet, it will be seen that an immense mass of ice must have existed to give the pressure necessary to overcome such a rise, and in all probability this energy was largely used up in overcoming this obstacle, for we find, from the glacial striæ on the southern slopes of the summit, that the glacier followed and had its direction modified by the valleys of that slope, while any obstacle of magnitude caused the ice stream to turn from its direct course, in marked contrast to its action north of Lake St. John, where no obstruction appears to have had the power to more than slightly divert it from a uniform course.

Lack of
energy of ice
flow.

Divergent
glacial striæ.

The area included in this report shows this modified action ; the glacial striæ are here found to conform in direction with the courses of the river valleys, and the slopes of the higher isolated hills to the south. These striæ may have been the latest formed, and may have worn away older sets, which may have shown a more uniform direction for the ice flow at the period of maximum glacial development ; evidence of more than one set of striæ have been found on the limestones, and in a few places on the gneiss, but these older striæ are too few, and are not uniform enough, to show that at an earlier time during the period of glaciation, any other motion than that recorded by the later striæ prevailed.

The following list of striæ observed in this area shows the diversity in direction of the ice movement, and nearly all of them are parallel to some valley or prominent slope, in the immediate neighbourhood of the place where they were observed.

List of Glacial Striae.

List of glacial Quebec and Lake St. John Railway, summit between Black striæ.	°
River and Lake Simon.....	S 25 E
One-quarter of a mile east of last.....	S 20 E
Quebec and Lake St. John Railway, half a mile east of Lake Simon.....	S 28 E
Quebec and Lake St. John Railway, one mile east of Allan's mill	S 7 E

Fourth Range Bourg Louis, one mile east of Allan's mill....	S 8 W	Glacial striæ.
On hill near Ry., three-quarters of a mile east of Allan's mill	S 55 W	
West side of North Branch of the Ste. Anne River on hill, near mouth of the Mauvaise River.....	S 23 W	
West side of North Branch of Ste. Anne River, on hillside half a mile north of mouth of Mauvaise River.....	S 23 W	
West side of North Branch of Ste. Anne River, one mile north of mouth of Mauvaise River.....	S 13 W	
On road between II. and III. Range, Bourg Louis, on summit of hills south of Ste. Anne River.....	S 55 E	
On road of IV. Range, Bourg Louis, rolling country.....	S 3 W	
Quebec and Lake St. John Railway, near Bourg Louis station.	S 18 W	
Road between Fossambault and Bourg Louis, on hillside, north of Lake Sargent.....	S 33 W	
Road between Fossambault and Bourg Louis, on hill top, south of Ste. Anne River.....	S 25 W	
Road between Fossambault and Bourg Louis on hill top, north of Lake Sargent.....	S 33 W	
River Ste. Anne, two and a half miles above Talyrade River	S 15 W	
River Ste. Anne, at mouth of Talyrade River.....	S 13 W	
North Branch of Ste. Anne, near V. Range, Gosford.....	S 5 W	
North Branch of Ste. Anne, at Pointe des Fourches.....	S 12 W	
Ste. Anne River, at Jackson's fall.....	S 22 W	
Ste. Anne River, at head of Kelley's rapid.....	S 35 W	
Ste. Anne River, at foot of Kelley's rapid.....	S 30 W	
Ste. Anne River, near east line of Jacques Cartier.....	S 4 E	
Ste. Anne River, two miles below Jacko River.....	S 60 E	
Road from St. Basile towards Ford's mill, one mile from St. Basile.....	S	
Road from St. Basile towards Ford's mill, two miles north of last	S	
Road from St. Basile towards Ford's mill, near the river....	S 20 W	
Road on D'Auteuil line, where it bends across Jacques Cartier, north of low gneiss hills	S 25 W	
Road between St. Paul and St. Charles parishes, Portneuf.	{ S 25 W S 50 W S 85 W	
Road on fifth range Portneuf, two miles south of Ste. Anne River, flat country		S 70 W?
Road on fifth range of Portneuf, one-quarter mile south of last, on hill.....		S 13 W

Glacial striæ.	Road on third range of East Grondines, flat limestone	S 7 E
	Road west of Portneuf River, Ste. Marie parish	{ S 12 E S 20 W
	Road west of Portneuf River, one-half mile north of last . . .	{ S 10 E S 35 W
	Near Episcopal church, third range, Portneuf	S 10 W
	At forks of roads near church, third range, Portneuf	S
	Road, fourth range, near east line of Portneuf	S 8 W
	Road on east line of Portneuf, one-quarter mile south of Canadian Pacific Railway	S 17 W
	Road, third range Portneuf, near junction with road to Portneuf village	S 15 W
	Road, fourth west of Portneuf, on north of Canadian Pacific Railway	S
	At La Chevrotière quarries	{ S 43 E S 23 E
	Road from Ste. Catherine to St. Gabriel station	S 40 E
	Falls of Jacques Cartier River, south of Ste. Catherine	S 40 E
	Road on fourth range of Fossambault	S 50 E
	Road south from Ste. Catherine, near road between fifth and fourth ranges west of Bonhomme Mountain	N 85 W
	On road between sixth and fifth ranges Fossambault, west of Bonhomme Mountain	W
	On road south from Ste. Catherine, in front of fourth range west of Bonhomme Mountain	{ N 80 W N 70 W
	On road second range Fossambault, south-west of Bonhomme Mountain	S 47 E
	On line between Fossambault and Des Maures, south of Bonhomme Mountain	S 45 E
	Lake St. Joseph, opposite mouth of Rivière aux Pins	S 23 W
	Lake St. Joseph, at East Point	S 20 E
	Jacques Cartier River, three miles above Ste. Jeanne de Neuville	S 5 W
	Quebec and Lake St. John Railway, at Belanger's siding . . .	S 15 E
	Quebec and Lake St. John Railway, one-quarter mile west of Belanger's siding	S 15 E
	Quebec and Lake St. John Railway, east of Lake Sargent . .	S 30 E
	Quebec and Lake St. John Railway, one mile east of Portneuf River	S 15 W
	Quebec and Lake St. John Railway, one-quarter mile east of Portneuf River	S 35 W

° Glacial striae.

Quebec and Lake St. John Railway, 300 yards east of Lake	
St. Joseph station	S 30 W
On hill, east of Valcartier	{ S 70 E S 60 E
On hillside, Jacques Cartier River, near east line of St. Ignace	S 80 E
On hillside, Jacques Cartier River, one-half mile beyond last.	S 45 E
Road on west side of Jacques Cartier River, above Valcartier	
bridge on lower hillside	S 70 E
On same road as last, on mid-hill	{ S 72 E S 45 E
On same road as last, on mountain summit	S 45 E
On same road as last, on mountain between the Jacques	
Cartier and Rivière aux Pins	S 45 E
Same as last, on summit of mountain	S 75 E
On road up east side of Jacques Cartier River, at west line	
of Stoneham	S 85 E
On same road as last, at line between Stoneham and	
Tewkesbury	S 63 E
On Stoneham Road, north of fifth range	S 55 E
On Stoneham Road, in fourth range	S 75 E
On Tewkesbury Road, second range, near south forks of roads.	S 75 E
On upper road from Stoneham to Jacques Cartier River, in	
second range of Stoneham	S 55 W
On the same road as last, in III. range of Stoneham	S 67 W
On road from Stoneham to Charlesbourg at south line of	
Stoneham	S 60 W
On same road as last, two miles south of last	S 53 W
On same road as last, one mile south of last	S 53 W
On same road as last, along the face of Archæan escarpment	S 55 W
On north-east flank of mountain, on road from Valcartier to	{ S 35 W S 50 W
Lorette	
On hill immediately north of Lorette	S 50 W
On hill north of road from Lorette to Charlesbourg	S 60 W
On road north-east of Lake St. Charles, near bridge over	
River Hurons	S 15 E
On road from Charlesbourg to Lake Beauport, where it	
descends to valley of River Jaune	S 75 E
On same road, 100 yards up River Jaune	{ S 70 E S 50 E
On north side of Lake Beauport	S 55 E

Glacial striæ. On road on west side of Montmorency River, quarter mile above Beauport road	S 45 W
On same road, two miles above the Bras, high on hillside... S 20 E	
On road up west side of the Bras	S 75 W

Till.

Extent of distribution.

Till is found everywhere throughout the Archæan area, covering to a greater or less thickness the rounded hills ; and only in the valleys of the rivers and their tributaries, is it removed or concealed by later stratified deposits of sands, gravels and clays of fluviatile origin.

On the lower levels of the Archæan spurs to the southward, the presence of drift is nearly always noticeable, even below the level of the later stratified deposits of marine sands and clays.

Absence of thick deposits on lower area.

On the still lower margin of Palæozoic rocks along the St. Lawrence thin deposits of coarse grey sand, with numerous large boulders, are often seen resting on the underlying rock ; these are probably the remains of large masses of till which have first been deposited on the bare rocks, and then washed away by the strong current down the wide valley of the St. Lawrence during the subsequent subsidence, only the large boulders with small patches of coarse sand and gravel escaping from the transporting action of the waters. On this southern margin the only thick deposits of till are seen in the ancient river mouths, those of Portneuf and Jacques Cartier are most noticeable ; the mouths of these streams in pre-glacial times were much wider than now ; at present they discharge into the St. Lawrence through narrow valleys, cut out between the till and shales on the western side of the ancient valleys, while the remainder of these ancient valleys is blocked up with till. In the Jacques Cartier River the till extends eastward from the present mouth to the shale cliff, a distance of one mile, and the deposit presents a bold escarpment in height equal to that of the shale. The extent of the till deposit in the ancient mouth of the Portneuf River cannot be so well defined, as it is overlaid by deposits of stratified sands, but the shale cliff does not come out on the St. Lawrence for two miles from the present mouth.

Boulders.

All inequalities and ancient watercourses cut into the cliff of limestone or shale along the St. Lawrence have been filled with coarse till, while large boulders are plentiful along the top and face of the escarpment and on the beach below, where they are chiefly found on the points and in lines across the small bays from point to point, having been arranged in this manner by floating ice on the tidal waters of the St. Lawrence.

The scattered boulders resting on the limestones and shales appear, Moraines, in places, to be roughly arranged in lines, and are probably the remains of lateral moraines ; a striking example of this arrangement is the one on which the village of Deschambault is situated. This band of boulders can be traced from the foot of the Archæan spur, across the road running north from the village, and culminates on the river front in a prominent point which rises seventy feet above the water and extends backward behind the village over a-quarter of a mile. This hill is almost wholly made up of large boulders of gneiss, from which many of the houses of the village are constructed.

At the Grondines lighthouse another band comes out on the St. Lawrence, and can be traced northward to beyond the railway in the third range, where a huge boulder of gneiss, ten by ten, by fifteen feet, is seen resting on the bare limestone immediately south of the track.

On the east side of the Portneuf River, between St. Basile and Cap Santé, boulders are again numerous without signs of being laid down in bands, but are loosely scattered about in sandy drift. West of Pointe aux Trembles spur, boulders are seen in a similar condition ; and again on the plain of the St. Charles River, south of the Archæan escarpment at Lorette ; on the west side of the river the boulders are most plentiful, and lie roughly in bands, one band running south parallel to the old line of the Quebec and Lake St. John railway.

The composition of the till varies as to the amount of sand and clay which go to form its finer parts, but the former generally predominates.

On the higher portions of the Archæan area the smaller material of the till has a sub-angular character, showing that it has not been subjected to any great friction, and consequently that it is not far travelled; the inclosed boulders also bear out this fact, the majority coming from rocks of the immediate vicinity, while the far-travelled ones do not make one per cent of the whole.

Character and
composition of
till.

On the lower levels about the southern face of the Archæan, the drift as a whole is much more rounded and worn.

Kames.

The almost unbroken forest which covers the northern area, where the till is most highly developed, and the absence of similar deposits in the more settled southern country makes it impossible to enter into a detailed study of structure in the till, except in the larger river valleys.

In the Ste. Anne de la Pérade River valley, that portion east of Ford's Fall, and southward to the vicinity of the Island bridge, has an <sup>Kames of Ste.
Anne River
valley.</sup>

uneven surface, which forms a succession of low rounded hills arranged with their longer axes parallel to the valley. These hills are made up partly of till and partly of stratified, coarse, yellow sands, and their lower portions were probably formed under the valley glacier, while the upper parts are largely made up of stratified sands of post-glacial age, as they are below the level of subsidence, and they have been subsequently modified by the cutting action of the river, so that they cannot be termed wholly glacial kames in the strict sense of the term.

Jacques
Cartier River
valley kames.

On the Jacques Cartier River, at the Quebec and Lake St. John Railway bridge, and for some two miles below, similar rounded sandy hills are seen ; these, where cut for ballast pits, show a composition of coarse sand and small gravel, with numerous large boulders, not well stratified, and evidently only modified till, laid down under the glacier of the Jacques Cartier valley. These low hills extend along the west side of the river, and separate it from a large peat swamp which extends from these hills to the foot of the Archæan mountains of St. Gabriel. The area of the swamp is over ten square miles.

Montmorency
River.

The kames along the west bank of the Montmorency River, above the lower road to Lake Beauport, are similar to those of the Ste. Anne, and probably owe their origin more to river than to glacial action.

Stratified Deposits.

At the close of the period of glaciation a period of marked depression occurred, the land sinking to at least six hundred feet below its present elevation, as shown by the stratified deposits of marine clays and sands which now overlie the till up to that elevation.

Extent of sub-
sidence.

During this period of submergence the sea extended inland up the valleys of the rivers tributary to the St. Lawrence, forming wide, deep estuaries in which thick deposits of sand and clay were laid down.

Cause of ab-
sence of strati-
fied deposits
along the St.
Lawrence.

Such deposits
elsewhere.

Only along the margin of the Archæan highlands, and in a few isolated patches protected from the river currents, are similar deposits seen on the lower lands facing the St. Lawrence, showing that the force of the currents in that stream during the period of subsidence was sufficient to carry away any clay or sand brought down by its tributaries, and so prevented the formation of thick stratified deposits similar to those found in the wide mouths of the smaller streams. These strong currents of the St. Lawrence were probably only local, and were caused by the contraction of the great river between the highlands north and south of the area under consideration ; as to the westward, where the old valley broadens, extensive deposits of clay and sand are found laid down in the valley, in marked contrast to the

low lands of this portion, where the surface covering of the limestones and shales is very thin, and often of clay formed from the direct disintegration of the under-lying shales, sometimes of the remains of till patches, and seldom of stratified clay and sand.

These stratified deposits are easily divided into two groups ; the first laid down in tidal waters in the estuaries of the rivers below the ancient sea level ; the second in the upper valleys of the rivers and their tributary streams. The former are made up altogether of clay laid down beneath sand ; the latter chiefly of interstratified sands and gravels, with few beds of clay.

The limit and extent of the subsidence is marked by the terraces seen along the flanks of the Archæan highlands ; and their marine origin is proved by the presence of fossil marine shells in some of the beds. These shells do not appear to have existed any great distance up the estuaries. Their highest limit in the Ste. Anne valley is near where the west line of Portneuf seigniory crosses the river, between the junction of the Archæan and Trenton, at an elevation of one hundred and fifty feet above sea level. Although the fossils are not found beyond this point, the clays and sands have undoubtedly the same origin to beyond the forks with the North Branch at St. Raymond. Proceeding eastward, the next locality where Post-pliocene shells were found is on the banks of Belisle River, where it crosses in the third range, the second road running back from the St. Lawrence west of Portneuf, and in rear of the higher part of the Deschambault spur, with an elevation of three hundred and ten feet. Fossils are abundant in the thin sandy clay resting on till, at the first rise of the road immediately west of Portneuf, and are also found on the banks of the Rivière aux Pommes, where the road from Pointe aux Trembles to the White bridge crosses it ; here the elevation above sea level is one hundred and seventy-five feet.

The next locality is important as it is the highest level at which these fossils have been found in the vicinity of Quebec, and one of the highest in eastern Canada. It is in a cutting immediately north of St. Ambroise station on the old line of the Quebec and Lake St. John railway. Here a thin deposit of stratified clay rests upon hummocks of till, the thickness of the clay beds varies from five to ten feet, and they are overlaid by stratified coarse yellow sand. In the highest bed of the clay *Saxicava rugosa* is found. The fossil bed does not exceed eighteen inches in thickness. The altitude of these deposits, from the railway profiles, is five hundred and fifteen feet above high tide level at Quebec.

Numerous
fossils.

On the summit of the road from Beauport to Bourg Royal a thin deposit of arenaceous clay, resting on the shales, holds fossils at an elevation of two hundred and sixty-five feet. On the Beauport River, in the gulley behind the old mill, thin beds of stratified sands and gravel overlying a thin bed of sand which rests on till, hold a great number of species especially in the lowest sand bed.

To the eastward of the Montmorency River the margin between the Archæan highlands and the shore of the St. Lawrence is very narrow and terraces everywhere flank the high hills. The lower ones rest on the plateau of the Cambro-Silurian rocks which rises a short distance behind high water mark and extends inland rising by a succession of terraces as the higher hills are approached.

Terraces.

Terraces of this description are met with crossing the roads leading up the valleys of the Sault à la Puce, Chiens and Ste. Anne rivers. From the mouth of the Ste. Anne River to the foot of Mount Ste. Anne nine terraces are passed on the road to St. Férol having respectively elevations of fifteen, twenty, twenty-six, one hundred and fifty, one hundred and eighty-five, two hundred and fifty, three hundred and ten, three hundred and fifty-five and five hundred and seventy-five feet above sea level.

On the road back from Ste. Anne church, Post-pliocene shells were found at the foot of a terrace two miles and a half inland, and three hundred and eighty-five feet above the present sea level.

The following species of Post-pliocene fossils have been determined by Sir J. W. Dawson, from the vicinity of Quebec, the greater number coming from the Beauport locality :—

*List of Post-pliocene Fossils. **

- Lagena sulcata* (var. *distoma*).
" " (*var. semisulcata*).
Entosolenia globosa.
" *costata*.
" *marginata*.
" *squamosa*.
- Bulimina Presli*.
" (*var. squamosa*).
Pulvinulina repanda.
Polystomella crispa (var. *Striatopunctata*).
" " (*var. Arctica*).

* Sir J. W. Dawson, "Canadian Naturalist," New series, vol. vi., 1871, pages 254-256, 370-470.

Nonionina scapha.

“ “ (var. *Labradorica*.)

Textularia pygmaea.

Quinqueloculina seminulum.

Biloculina ringens.

Triloculina tricarinata.

Strongylocentrotus Drobachiensis, Müller.

Hippothaea axtenularia, Jameson.

“ *expansa*, Dawson.

Tubulipora flabellaris. Johnston.

Lepralia hyalina, Johnston.

“ *pertusa*, Johnston.

Rhynchonella psittacea, Gm.

Saxicava rugosa, Linn.

Mya truncata, Linn.

“ *arenaria*, Linn.

Macoma Grænlandica.

Macoma calcarea, Chemnitz.

Astarte Laurentiana, Lyell.

“ *Banksii*, Leach.

Serripes Grænlandicus, Chemnitz.

Mytilus edulis, Linn.

Mödiolaria discors, Leach.

Leda (Potlandia) glacialis, Grey ; *L. truncato*, Brown.

Pecten Islandicus, Chemnitz.

Puncturella (Cemoria) Noachina, Linn.

Lepetæ cæca, Möller.

Bela harpularia, Couthouy.

Natica affinis, Gmelin. (*Natica clausa*, Brod. and Sowerby.)

Lunatsia heros, Say.

“ *Grænlandica*, Beck.

Velutina zonata, Gould.

Scalaria Grænlandica, Perry.

Acirsa Eschrichtii, Holboll.

Chrysodomus tornatus, Gould.

Spirorbis vitrea, Fabricius.

Balanus Hameri, Ascanius.

“ *porcatus*, DaCosta.

“ *crenatus*, Brug.

The elevation of six hundred feet to which the highest beds of sand of undoubted marine origin were deposited, must not be taken as the

Thickness of stratified deposits.

thickness of these deposits, as they were laid down on the irregular sloping surface of the ancient sea bottom, and at present nowhere exceed two hundred feet in any section, while seventy-five of sand and one hundred feet of clay would probably cover the thickness of the greatest deposit in any single place throughout this area.

Marine Terraces.

Level of highest terraces.

The elevation of the highest terraces, with their cut faces towards the lower open country of the St. Lawrence, is more than six hundred feet above the present sea level.

Terraces from St. Raymond south to the St. Lawrence.

On the east side of the Ste. Anne River, south of St. Raymond, is a generally level drift plain, extending southward through Bourg Louis and St. Basile to the St. Lawrence. This plain is broken into a succession of terraces, and separated by a number of sharp rises which all face toward the open country, and are only slightly modified by the small local river valleys. The highest of these terraces is immediately behind St. Raymond, where the land rises in two river terraces of ten and one hundred and twenty feet to the plain above, at an elevation of five hundred and eighty feet above sea level. From here the surface is nearly level on the road to Bourg Louis for one mile, where it descends sharply over two small terraces, each twenty feet below the last. The cut faces of these terraces, composed of coarse yellow sand, can be traced from the base of the gneiss hills on the road between St. Raymond and Bourg Louis station, westward across the Bourg Louis road and then along the north side of the road to Jackson's mill, where they are lost in the river terraces. Below these, the next sandy terrace extends from the foot of the gneiss hills near Lake Sargent, westward towards the Ste. Anne River, its cut face crossing the Bourg Louis road to the south of the Episcopal church and passing south-west, touches the road from St. Basile to Ford's Fall, one mile south of the Ste. Anne River, where it passes into the kame structure before described.

Portneuf River valley.

From the foot of this terrace, three hundred and fifty feet above the sea, the country passes downward to the valley of the Portneuf River near St. Basile, by four narrow terraces, having faces of thirty, sixty-three, twenty-seven, and thirty-five feet front elevation ; the soil is stratified greyish-blue clay overlaid by thin beds of dark yellow ferruginous sand.

West side of Ste. Anne River.

The Ste. Anne River valley is cut deep into similar deposits of clay and sand, along the base of the crystalline rocks on its west side ; and between it and the hills of the Deschambault spur, the land slopes away from the Ste. Anne with distinct terraces towards the open St. Lawrence valley.

These terrace faces are well developed on the road from La Chevrotière to St. Alban and thence along the road on the east side of the Ste. Anne River to the Island bridge. To the west of Deschambault, the first rise along the St. Lawrence margin is at a distance varying from one to six hundred yards from the present shore line. This rise, where the limestone cliff is not present, is generally low and nowhere exceeds fifty feet in elevation ; it is followed by slowly rising ground, underlaid by limestone without a sufficient covering of surface material to produce marked terraces ; this continues until the swampy land of the fourth range (elevation one hundred feet) is passed, when sandy terraces are met with roughly facing the St. Lawrence, and rising towards the Ste. Anne River.

The first of these commences near the Ste. Anne, one mile and a half south of St. Alban bridge, and has a rise of sixty feet. It crosses the St. Alban road one mile and a half to the north of the quarries, and the La Chevrotière River in the middle of the third range ; it then turns south-west, crosses the range road and is lost against the gneiss hills, along the west side of Belisle River.

The next terrace behind has a rise of twenty-eight feet ; its face crosses the road along the east side of the Ste. Anne, three-quarters of a mile to the north of the St. Alban road, whence it sweeps around the swampy land at the head of the La Chevrotière River, and crosses the fourth range road a short distance to the east of the river, and then runs south between the hills and Belisle River to near the second range.

Beyond this terrace on the Ste. Anne road the rise is gradual, from one hundred and ninety to two hundred and fifty feet, to where it joins the fifth range road of Portneuf ; here a rise of thirty-five feet is made to a flat sandy terrace, and soon followed by another thirty feet higher ; these skirt the Archæan hills between the Ste. Anne River and Deschambault ; they are met with in their southern course crossing the third and fourth ranges to the east of the road running north from Deschambault station, and die out to the north of the third range road.

These terraces are followed to the north of the hummocky country, between the Island bridge and Ford's fall by the higher terraces before described, which reach to near St. Raymond.

The Archæan hills cross from the North Branch to the Ste. Anne River, about five miles above the junction of these streams, and with them form a narrow triangle of stratified drift-covered land, with the base three miles in length, along the foot of the hills. This triangle forms a high plain, with terraced faces towards the rivers, and with the exception of a narrow ridge along the Ste. Anne face, the general level is 635 feet above the sea ; the surface soil is a coarse yellow sand.

Low lands
along St.
Lawrence.

Absence of
drift.

Terraces in
Ste. Anne
River valley
facing St. Law-
rence.

Terraces be-
tween Ste.
Anne River
and the North
Branch.

Highest estuarine deposit.

Terraces facing Ste. Anne River.

Terraces on west side of North Branch

Section of stratified deposits.

Terraces on west of Ste. Anne River.

The higher ridge referred to has a breadth of one-quarter of a mile in the widest part, where the road up the North Branch crosses it, and extends along the margin of the Ste. Anne escarpment, terminating in a round hill behind St. Raymond. This ridge is quite flat on top and has cut faces on either side, rising thirty-five feet above the general plain, and evidently laid down as a narrow point between the mouths of the rivers. Its elevation, six hundred and seventy feet above sea level, is the highest at which stratified estuarine deposits have been noted in this region.

In descending from this ridge towards the Ste. Anne River, the first drop of thirty-five feet is followed almost immediately by another of fifteen feet, to a narrow terrace, from which a steep descent of one hundred and twenty feet brings the road to the level of the river valley, only a few feet above the stream. In the last descent the cut face shows the upper twenty-five feet to be sand and the remainder grey clay.

These two principal terraces are seen facing the North Branch in a similar manner, beyond the low lands, which extend from the point of the forks one mile up both streams.

On the west side of the North Branch and of the Ste. Anne River south of the forks, similar terraces are met with. On the road from St. Raymond, crossing the North Branch at the black bridge, a low swampy clay flat, ten feet above the river bed, is passed over to the first rise of sixty-five feet, half a mile from the river. The section of the cut face here gives, in ascending order, thirty-five feet of stratified clay, fifteen feet coarse grey sand, ten feet yellow sand, eighteen inches fine gravel, eighteen inches yellow sand, and two feet of fine gravel on top.

From the top of this rise the road passes backward three-quarters of a mile over a sandy and generally swampy country to the second rise, of eighty feet. This terrace is composed of yellow sand, and its top is six hundred and ten feet above sea level. Behind this the country gradually rises to the gneiss hills, and the evidence of cut terraced faces at a higher level than the last are wanting.

The face of this upper terrace can be traced from the high lands north of the railway on the road along the west side of the Ste. Anne to the rocky hill at the junction of the Mauvaise River with the North Branch.

To the south as far as the island bridge on the west side of the Ste. Anne, and between it and the Archæan hills, terraces closely corresponding in height to those of the more open country on the east side

of the river, flank the hills and face diagonally towards the river valley. The elevation above sea level of the principal terraces on the west side are as follows : 556 feet, 515 feet, 480 feet, 420 feet, 410 feet and 365 feet.

Between Deschambault village and the Portneuf River two marked terraces, cut out of the boulder till, along the foot of the Archæan hills, are crossed by the roads running back from the St. Lawrence. On the road to the Deschambault station the first rise is three-quarters of a mile behind the river road, and the difference in elevation between its foot and top is eighty-five feet ; the second rise, of thirty feet, is at the crossing of the second range road.

Terraces cut out of till.

On the road one mile west of Portneuf the first rise from the St. Lawrence, of forty-six feet, occurs 350 yards behind the river road. Here the face is composed of boulder drift with thin patches of sandy clay resting on it and holding *Leda truncata*. Beyond this the road rises gradually to the foot of the gneiss hills.

Portneuf River Valley.

The road from Portneuf village to the railway station first passes over a clay terrace forty feet above the river, then as the station is approached two other terraces of one hundred and ten feet, and one hundred and fifty-five feet elevation, the lower having a sandy clay face, the upper composed of sand.

Similar terraces are met with on the west side of the Portneuf River and its tributary the Claude, extending to the base of the low hills which cross to the eastward behind St. Basile.

Along the St. Lawrence to the east of the Portneuf River the cliff is composed of till for two miles, and its face is roughly terraced, but not markedly so, except along the side towards the mouth of the Portneuf ; here on the road to St. Basile station are terraces of twenty, forty-five, sixty-two, one hundred and thirty, one hundred and fifty-five, and two hundred feet, the last two being inland from the river and front towards the Portneuf valley. The cliff on the road which descends to the St. Lawrence one mile and a half to the east of the last, has an elevation of one hundred and seventy-five feet with a gentle rise behind to the summit of the land facing the Portneuf valley.

To the eastward the lower part of the escarpment of till is gradually replaced by a cliff of shale which comes out on the river front and is ninety feet high at Cap Santé while the terrace of till behind is eighty-five feet higher ; farther on towards the mouth of the Jacques Cartier River the two combine and present a bold cliff one hundred and eighty feet high.

Behind this region the drift is thin without marked terraces until the Canadian Pacific railway is crossed, when a sandy terrace rises

Absence of terraces.

sixty-five feet from the lower clay plain of the Portneuf valley, this has an elevation on top of three hundred and twenty feet above sea level. It was traced from the east side of the Portneuf River, near its abrupt bend to the westward in the parish of St. Charles, southward parallel to the Terrebonne road, to the junction of that road with the one to St. Basile station, thence continuing southward to near Ste. Jeanne de Neuville station, where it turns northward forming a sharp point, and again crosses the St. Basile road, and sweeps round to the eastward crosses the Ste. Catherine road one-half mile to the east, and continues as a river terrace up the west side of the Jacques Cartier River.

*Jacques
Cartier
Rivey valley.*

A second small terrace of twenty feet higher is passed over on the roads between the Jacques Cartier and Portneuf rivers, with cut banks facing in both directions.

*Terraces on
west side of
Jacques
Cartier River.*

On the road to Ste. Catherine along the west bank of the Jacques Cartier several terraces cross the road obliquely, extending from the base of the gneiss hills, which lie to the west of the road, in a diagonal course to the Jacques Cartier River, and although laid down in the wide valley of that stream are evidently of marine origin and distinct from local river terraces. Here the next rise of thirty-five feet is passed one-quarter of a mile beyond the last, and is followed one mile farther on by another of forty-six feet with one of forty-five feet half a mile beyond the last, after this the country rises gradually to an elevation of five hundred and fifty feet near the road to Lake Sargent, on which at the rear of the fourth range of Fossambault a final terrace of thirty feet occurs along the base of the gneiss hills, which are covered by unstratified till above this level.

Continuing along the Ste. Catherine road, it has an abrupt fall of one hundred and thirty feet, where it descends to the valley at the mouth of the Rivière aux Pins, where the cut face shows a thickness of one hundred feet of grey clay overlaid by thirty feet of stratified yellow sand.

*Terraces about
St. Gabriel.*

On crossing this valley the road again rises to the level of the flat plain about Ste. Catherine station, where a short distance to the eastward the terrace divides into two, the upper being about thirty feet above the lower, and skirts along the base of the rocky hills on the north side of the great swamp extending to near St. Gabriel station.

Eastward from that place a wide sandy plain extends from the hills on the north to near the banks of the Jacques Cartier. This plain has an elevation of six hundred and five feet above sea level, and is flanked on its south side by a terrace of clay fifty feet below it and twenty feet above the river. The upper terrace may be traced to the bridge at Valcartier, above which it becomes very narrow and is soon

lost on the rocky hill side which here encroaches on the river. The lower terrace is somewhat wider, and continues up the river valley above the bridge, its clay being gradually replaced by sand and gravel of river origin.

On the east side of the river, terraces corresponding to those already mentioned, are noticeable. The lower clay terrace forms a large swamp which extends from the river margin to the foot of the second rise. East side of Jacques Cartier River.

The road from Valcartier bridge to Lorette rises over escarpments of twenty-five, thirty-five, and ten feet in the first mile from the river to a sandy plain six hundred and five feet above sea level, which stretches southward between rocky hills until cut off by the high lands north of Lorette.

The road from Valcartier to St. Ambroise first runs three-quarters of a mile over this plain and then crosses a boulder-strewn hill over Valcartier one hundred feet higher, and descends again to the plain one mile plain. further on. The descent on the west side first reaches a narrow terrace of sand at six hundred feet elevation, and then two others ten and fifteen feet lower, the latter extending to within one mile of Valcartier station where it drops by three steps of ten, twenty and ten feet to the flat sandy plain between the Bonhomme Mountain and the hills to the west of the Nelson River, which extends southward to the edge of the Archæan rocks at St. Ambroise, where it drops abruptly over the shales, which have only a thin covering of drift.

From the head of the St. Ambroise rise to the Jacques Cartier River at the Quebec and Lake St. John railway crossing, the rise is only thirty feet. The western limit of the plain skirts the foot of Bon-
Western limit. homme Mountain and crosses the road south from Ste. Catherine in the rear of the fourth range of Fossambault; its northern limit extends to within half a mile of the Jacques Cartier, descending to that stream by escarpments of seventy-five, twenty and ten feet. From the southern limit of the plain the road rises abruptly thirty feet, to a swampy plain which extends to the foot of the mountain in the third range, where a small brook has cut forty feet into the déposits, and shows ten feet of yellow sand overlying stratified greyish-blue clay. Just beyond the brook the highest terrace is seen on the flank of the mountain, at an elevation of six hundred and thirty-five feet, the road beyond as it rises over the mountain passes over unstratified till. Section of stratified deposit.

Between Ste. Catherine and Ste. Jeanne de Neuville the rocky hills on the east side of the Jacques Cartier River lie close to the water, leaving only a narrow fringe of stratified sands and clays, with narrow and less marked terraces than on the opposite side.

Absence of drift.

As before stated, little drift material is left on the lower country south of the Archæan area, and the remains of terraces in that portion of the country east of the Jacques Cartier River are so often broken and indistinct that it is impossible to trace them in detail. East and north of St. Ambroise to the valley of the Montmorency River, the country is rough, with only a small proportion open to the St. Lawrence below the level of six hundred feet, and consequently the marine deposits are only slightly developed, as in the valley of the St. Charles River, where stratified clays overlaid by sand are found cut into terraces up to Lake St. Charles, where the highest one noted is five hundred and forty feet above sea level.

Montmorency River valley.

The road up the west side of the Montmorency River passes over flat beds of limestone, generally covered with soil, from a few inches to a few feet thick, to the middle of the first range where the road rises slowly over thirty feet of yellow sand to a terrace of that material at the second range, three hundred and fifty feet above the sea. The face of this terrace again crosses the second range road one-quarter of a mile west of the Laval road, and is lost in the driftless area to the westward.

Passing northward a terrace of forty feet is crossed before the third range is reached, where two hundred yards beyond the road climbs the steep face of a sandy terrace one hundred and forty-five feet above the last; this is immediately followed by another rise of thirty-five feet to a flat, sandy plain, which extends from the rocky hills to the west, to the edge of the river valley. This plain is five hundred and seventy-five feet above the sea, and continues northward two miles, with a few small rocky knolls covered with till projecting from it. Beyond this the high rocky hills encroach from the westward, causing the plain to gradually narrow, while the knolls are more frequent until the road crosses a small brook, when its elevation varies from five hundred and eighty to seven hundred and fifteen feet, as it passes over sandy till to a second brook half a mile beyond; this brook is crossed at an elevation of six hundred feet, and its cut banks are made up of stratified coarse sand and fine gravel, which is probably of local fluviatile origin.

Beyond this the road descends to the river valley, which it now follows closely; at its junction with the lower Lake Beauport road, the river is five hundred feet above the St. Lawrence, so that although beyond this point terraces line either bank, they have probably been laid down by running waters in the old river valley, and mark flood levels rather than old sea shore lines; their composition of sands and gravels point to the same origin, and as such they will be considered later on.

River Terraces.

Above the level of the highest marine deposits along the valleys of the rivers and their tributary streams, stratified sands and gravels have been deposited and then cut into terraces facing the water. These deposits hold a great quantity of coarse material, showing that, unlike the marine beds, they have been laid down by waters having a sufficient current to transport coarse sand and gravels from their original sources and deposit them in stratified order as at present found.

These deposits are only seen along the upper portions of the water-courses in the northern part of the area included in the map, and as these are only partly cleared it is impossible to follow them with accuracy, and at times to see them at all except along the larger streams.

Along the River Ste. Anne gravel interbedded with sand and clay is first seen a short distance above St. Raymond, the number and thickness of these beds increase as the river is ascended until, at about five miles up, the clays are entirely replaced by coarse sand and gravel. On the road to Lake Sept Iles, where it rises from the river valley, these deposits reach to a height of ninety feet above the present water level, while on the north side of the stream a short distance above, six distinct terraces are seen, the highest being 120 feet above the river. Beyond this to the Talyrade River terraces continue to flank the rocky hills on the north side, two or three being generally distinguishable, of which the highest rarely reaches seventy-five feet. From here to the east line of Gosford the terraces become less marked and are small and local.

In the Jacques Cartier River valley similar terraces are seen above Valcartier bridge; they flank the gneiss hills on either side, but the highest never exceeds 100 feet above the water level. On the whole they are more marked and higher than those of the Ste. Anne valley; this is probably due to the narrowness of the valley, which would cause the waters to rise to higher levels during periods of flood.

In the Montmorency valley these terraces are especially noticeable on the point between the Bras and the main stream, where well marked terraces in stratified sand and gravel rise 120 feet above the water. On the sides of the smaller streams these deposits are seldom more than fifty feet thick, while about the shores of the various lakes similar sand and gravel deposits show that their ancient shore lines were considerably higher than at present. About Lake Beauport the terrace faces rise in places fifty feet above the present level, while at Lake Simon the stratified deposits are found from twenty-five to thirty feet above the lake.

Composition
of deposits.

Ste. Anne
River.

Jacques
Cartier River.

Montmorency
River.

Lakes Beau-
port and
Simon.

Probable origin.

These deposits of stratified sand and gravel, in the river valleys, show that at certain times their waters rose to the level of the highest bed. This rise was probably caused by freshets from the rapid melting of ice during the close of the glacial period, and was probably greatly augmented by dams of drift and ice, which formed temporary barriers that caused the rapid flow of water to deposit the sand and gravel at the high levels where they are at present found.

Swamps.

Iron ore and ochre.

East and West Grondines.

Bourg Louis.

St. Gabriel.

South of Ste. Catherine.

Valuable deposits of bog iron ore and ochre are found in the extensive swamps and small lakes in the district about the St. Maurice River a short distance west of the area under consideration, and as the conditions are the same no doubt similar deposits occur in the swamps of the Ste. Anne and Jacques Cartier basins. In the third range of East and West Grondines between the higher terraces of the Ste. Anne and the limestone of the second range, is a shallow swamp of considerable extent. An extension of this swamp passes north-east through the fourth range of La Tesserie and La Chevrotière, where near the head-waters of the La Chevrotière River, it is over one mile wide and is terminated in that direction by the sandy terraces crossing from the Ste. Anne River to Deschambault. On the west side of the Ste. Anne a peaty swamp occupies the greater part of Bourg Louis south of the railway and between the river and the Jacko Branch, where it rests upon the stratified clay, and is probably rich in iron ore as the sands of the surrounding district are strongly impregnated with the peroxide, and often hold lenticular beds of the same resting on the underlying clay or interbanded with the sand. No other extensive swamps occur in the Ste. Anne basin, but all the small depressions among the Archæan hills are either occupied by small lakes or swamps. In the basin of the Jacques Cartier the swamps are more extensive, the largest is that extending from the borders of the river to the gneiss hills between Ste. Catherine and St. Gabriel stations. The line of the Quebec and Lake St. John railway passes through it and the deep ditches along the line cut out of peat show that considerable decayed vegetable matter overlies the sands and clay below. The surface of this swamp is broken by a number of small ponds, while its solid parts are covered with a thin growth of small black spruce.

South of Ste. Catherine along the base of the Bonhomme Mountain swampy land occupies the greater part of the fourth range of Fossambault. The bottom lands on either side of Valcartier bridge are very low and swampy and unfit for cultivation. Much of the land along the Portneuf River to the east of St. Basile is low and swampy, the

water lodging on the tough impenetrable clay, but with a small expenditure on drainage the greater part of this land might be reclaimed.

On the road between Cap Santé and L'Enfant Jésus, there is a great bog with a breadth of half a mile. In the Grand Bois, on the west side of the Jacques Cartier River, swampy land extends for a distance of six miles, but is never very wide. Another swamp of considerable size lies to the east of Ste. Jeanne de Neuville ; the Canadian Pacific railway runs through the southern part of it ; this swamp extends eastward to the gneiss hills at the head of the River aux Pommes. Behind the rocky hills of Lorette and between the Quebec and Lake St. John railway and the St. Charles River, is another area of swampy land, which extends a couple of miles northward along the Nelson River. Other small areas of swamp are met with to the north and east of Lorette, between the Archæan hills.

ECONOMIC MINERALS.

With the exception of bog iron ore, ochre, building stones, brick clays and infusorial earth, no minerals of economic value are met with in the southern portions of the counties of Portneuf, Quebec and Montmorency.

Iron Ores.—Although grains and small patches of magnetite are common in the gneisses of this region, no deposit sufficiently large to be successfully worked is known. In the parishes of St. Charles, St. Paul and St. Eustache of the seigniory of Portneuf magnetite occurs freely scattered through the gneiss in grains varying from one-twelfth to one-half an inch in diameter. Large masses are found in the rocks of the mountain near the head of the Rivière aux Pins.

Ilmenite, as before stated, appears to be a constituent mineral of Ilmenite. the anorthosite rocks, in the rear of Château Richer, where besides being minutely distributed through the rocks, it is found in segregated masses up to four or five inches long and over an inch thick. According to Dr. T. Sterry Hunt, this ore forms one-hundredth of the mass, and in places five-hundredths.

Hæmatite was observed in the form of small crystalline masses in Hæmatite. several of the large pegmatite veins on the Ste. Anne and Jacques Cartier rivers, and along the line of the Quebec and Lake St. John railway, between Lake St. Joseph and Lake Sargent.

Bog Iron Ore.—Deposits of this mineral have for a long time been Bog iron ore. worked in the vicinity of Three Rivers, where it has been smelted in the St. Maurice Forges ; as the conditions under which it occurs there prevail in the western portion of the region under consideration, no

doubt extensive deposits of this mineral will be found in the swamps and lakes of the valleys of the Ste. Anne and Jacques Cartier rivers. In the Grand Bois, on the west side of the Jacques Cartier, there is a deposit said to extend parallel to the river, and to occur in patches for nearly six miles with a breadth of from fifty to one hundred and fifty yards. Between Portneuf and St. Basile, in the Bois d'Ail, there is a deposit extending over an area of four acres. Indications of this ore were also met with in the great swamp between Ste. Catherine and St. Gabriel, and also to the north of the Bonhomme Mountain. It occurs also, with ochre, in the swamp along the branch railway to Jackson's mill, and at the Pointe des Fourches, near St. Raymond.

Ochre.

Ochre.—Iron ochres are found in a great many localities, in fact, the stratified sand is nearly always highly impregnated with them, which gives it the dark yellow colour. The mineral often occurs in layers segregated out of the sands. These layers of ochre are most common when the sand is covered with swamp, and then often a considerable thickness of this material is found resting on the sand. Such beds are seen on the west side of the Ste. Anne River between the St. Raymond bridge and Jackson's mill, also on the Pointe des Fourches, while all the swamps before mentioned have deposits more or less extensive. In the parish of Ste. Anne de Montmorency, about a mile and a quarter above the mouth of the Ste. Anne River, there is a deposit of ochre extending over about four acres. The locality is on the top of the bank which overlooks the main road, from which it is removed about a quarter of a mile. The surface of the deposit has a slope to the south-east of about fifty feet in about one hundred and fifty yards, but the bottom of the deposit keeps nearly on a level with the lower side for some distance back, and then rises quickly up to the higher side. The thickness of the deposit is thus about seventeen feet to four feet. Three colours exist on the surface, yellow, red and blackish brown; but the lower and by far the larger part, is an ochre of whitish-green colour. In this green portion the iron is in a lower state of oxidation than in the yellow, but like it, becomes red upon ignition.

Large deposit.

Bog manganese.

Bog Manganese.—On the St. Louis road, about four miles and a half from Quebec, there is a small deposit of this ore. It occurs in black honeycombed masses imbedded in sand, and occupies an area of sixty yards by five yards wide, with a thickness of one foot in the middle gradually thinning all round.

Brick clay.

Brick Clay.—The stratified clays found extensively along the St. Lawrence margin and in the lower portions of the river valleys, answer admirably for brick-making. Bricks from these clays are made at St.

Raymond, and on the east bank of the Ste. Anne River below St. Alban. Extensive brick-yards are located in the valley of the St. Charles River along the Little River road.

Building Stones.—The different outcrops of Trenton limestone afford Building stone abundant quarries of this material. The beds of the upper and lower portions are liable to contain partings of black bituminous shale which cause the quarried stone to be generally of small dimensions when free from flaws. The beds of the middle part of the formation are very free from such partings and afford stone of dimensions up to six feet in thickness.

At St. Alban bridge, the gorge of the Ste. Anne River, for half a mile above and for two miles below, passes through these rocks, and any amount of good stone might be obtained there. The stone is light grey in colour, with a yellowish tinge, and is finely granular in texture.

In the rear of the fourth and front of the fifth range of La Chevrotière quarries. Chevrotière, extensive quarries have been worked for a number of years in beds of nearly the same horizon as the above. The stone has a yellowish-grey colour of even tint, and is not readily discoloured by weathering. Its texture is more granular than the Montreal stone, but it does not take so fine and sharp an edge, nor does it pick out so well. This stone has been used extensively for the large public works of Quebec, and is drawn from the quarries some two miles to the railway. The quarries, owned[®] by some seven individuals or companies, are opened on both sides of the St. Alban road for a distance of over a mile. The beds worked are only four or five in number, and as they lie nearly flat, and are near the surface, the quarries are only a few feet deep. The greatest thickness obtained here is 6 ft. 3 in., but this bed is liable to break into beds of 3 ft. 6 in. and 2 ft. 4 in.; above this is another of nearly 3 ft. thickness, overlaid by beds of 2 ft. and 15 in. in thickness. To the south of this locality, in the second range, smaller quarries have been worked in the past, but are now idle; the stone here, although hard and massive, is penetrated by thin partings of black shale, which soon weather on exposure and give the dressed stone a rough appearance.

At Pointe aux Trembles, extending over several lots, there is a grey limestone in massive beds, in which quarries have been worked. It has a colder tint than the stone of La Chevrotière and is less granular; it is not soft, but can be worked to a sharp edge. The beds yield good large blocks, and the stone has been used in Quebec for the construction of the Champlain market and other public buildings. At Cap Santé the black bituminous shales of the Utica formation are at

intervals interstratified with calcareous layers of two to six inches thick. They are of two colours, the upper dark grey and the lower light greenish-grey; the former are the more bituminous, the latter the harder and more calcareous, giving good lime when burnt. From the remarkable evenness and smoothness of these layers, they are well adapted for hearths, chimney jambs, sills and lintels, and are also excellent material for paving cellars and such like purposes. They are, however, jointed in various directions, and great weights, after the stones had been exposed to the weather for some time, might crack them in these joints. The joints are vertical to the plane of the beds, and they run chiefly in three directions, giving rise to two sets of rhomboids, one much more acute than the other. These beds are first seen about half a mile above the mouth of the Jacques Cartier, and thence extend along the beach to half a mile above Cap Santé church.

St. Ambroise. On the outcrops of limestone, from St. Ambroise eastward to Beauport, numerous small quarries have been opened and a large quantity of stone extracted for burning into quick-lime and for road metal. This stone is generally dark in colour, without a good granular texture, and is greatly divided by thin beds and partings of black bituminous shale, so that no blocks of any considerable thickness are obtainable.

Beauport. At Beauport, building stone of moderate dimensions is taken from large quarries on the hillside behind the village. This stone is of the same description as the above, and is used for private buildings in and around Quebec. In rear of Beauport to the Montmorency River, small quarries and accompanying limekilns are seen on nearly every farm lot. The limestone here is very thin bedded and greatly mixed with shale, and is useful only for lime-burning.

Château Richer. At Château Richer there are nine quarries in operation. The limestone is somewhat similar to that of Beauport, but of a better quality, being preferred by builders in the construction of private buildings in Quebec.

Gneiss.—Many of the bands of gneiss in the Archæan area would prove excellent material for the foundations of large superstructures, bridge piers, or harbour works, where superior strength and hardness are necessary.

But few attempts have been made to quarry these rocks, the abundance and good quality of the limestone leading to its employment for most purposes in which the gneiss might have been used. The cost of quarrying and dressing the gneiss is, of course, much greater than in the case of the limestone.

A quarry in a fine-grained, dark grey syenitic gneiss was opened at St. Basile and stone taken out for the walls of the church at that place.

This rock splits readily across the bedding in any direction, and may be obtained in blocks of fifteen inches in thickness. On the east side of the Jacques Cartier River, one mile south of the railway bridge at St. St. Gabriel. Gabriel, there is an outcrop of red, medium-grained syenitic granite, from which the stone for the railway bridge piers was obtained. This rock is an excellent building material. It works well, splitting easily into large blocks, and has a good colour when dressed.

The old dam of the Quebec waterworks, on the St. Charles River behind Lorette, was built of gneiss obtained from a quarry close by. Lorette. It splits in all directions by means of wedges, and is capable of receiving fine smooth faces with sharp edges. This rock is also hornblendic with a distinct gneissic structure.

At the St. Joachim falls, on the Ste. Anne de Montmorency River, St. Joachim. the rock consists of micaceous gneiss, of which the stratification is most beautifully and remarkably regular, without any twists or undulations. The rock is thin bedded, and although the beds appear to adhere pretty firmly together, it is probable that by the aid of wedges, large slabs might be split off with any required thickness, down to two or three inches, and would constitute an excellent material for foot pavements.

Infusorial Earth.—This substance, which is extensively used as a polishing powder, as well as for a non-conducting material and other purposes, consists of minute siliceous remains of diatoms. A considerable deposit of this earth is found on the twentieth lot of the second range of Laval settlement, which is on the right bank of the Bras, just Laval. at its junction with the Montmorency. The deposit is about fifteen feet thick and occurs in sand containing boulders, about forty feet above the river, and is overlaid by fifty feet of the same material. In colour it is partly yellowish and partly lead-grey, the colours being sometimes arranged in different layers, and sometimes irregularly intermixed in spots and patches.

Another deposit of this material occurs on the east side of the north branch of the Ste. Anne River in the ninth range of Gosford. This Gosford. deposit extends over an area of half an acre in the river valley ; it is of a lead-grey colour, and has been found to exceed four feet in thickness.

APPENDIX.

NOTES ON THE MICROSCOPICAL CHARACTER OF SOME ROCKS FROM THE COUNTIES OF QUEBEC AND MONTMORENCY, COLLECTED BY MR. A. P. LOW, 1889-91.

BY MR. W. F. FERRIER, B.A.Sc., F.G.S.

In the following short notes on Mr. Low's rocks a scheme of classification has been adopted about which it may be desirable to add a few words of explanation.

I am indebted to Dr. F. D. Adams, of McGill University, for his kind permission to make use of this scheme, which has not yet been published, but will appear in the forthcoming number of the Neues Jahrbuch für Mineralogie.

Dr. Adams proposes to apply the name "anorthosite," originally used by Hunt as a general term for the plagioclase rocks of the so-called Upper Laurentian, to those varieties of gabbro in which plagioclase very largely predominates. The plagioclase is, in nearly all cases observed, labradorite, but in a few instances it is andesite. This use of the term "anorthosite" has been approved of and adopted by Prof. Rosenbusch. The subdivisions of the gabbro family would then be as follows:—

<i>Labradorite (principally)</i>	<i>+ diallage</i>	\equiv <i>Gabbro proper.</i>
"	<i>+ rhombic pyroxene</i>	\equiv <i>Norite.</i>
"	<i>+ diallage + olivine</i>	\equiv <i>Olivine Gabbro.</i>
"	<i>+ rhombic pyroxene</i> <i>+ olivine</i>	\equiv <i>Olivine Norite.</i>
"	<i>+ olivine</i>	\equiv <i>Troktolite.</i>
"	<i>(alone)</i>	\equiv <i>Anorthosite.</i>

Then when the felspathic constituents of the rocks fail, we have:—

<i>Pyroxene (alone)</i>	\equiv <i>Gabbro Pyroxenite.</i>
<i>Diallage + olivine</i>	\equiv <i>Diallage Peridotite = Wehrlite.</i>
<i>Bronzite + olivine</i>	\equiv <i>Bronzite Peridotite = Harzburgite.</i>
<i>Magnetite + olivine</i>	\equiv <i>Magnetite-Oliveneite.</i>
<i>Olivine (alone)</i>	\equiv <i>Peridotite.</i>
&c., &c.	

Dr. Adams recently examined a few of the specimens from the Château Richer area, and in a communication to me calls attention to the following points noted in their examination :—

1. Plagioclase in all the specimens preponderates very largely, to the almost entire exclusion of the other constituents.
2. Most of the slides examined show excellent cataclastic structure.
3. A few of the specimens hold a very little quartz, principally in the crushed portion of the rock.
4. The coloured constituents when present consist of pyroxene, hornblende, biotite and ilmenite.

In the examination of the rocks here described untwinned grains of felspar have frequently been observed, but, as has been pointed out by G. W. Hawes*, many triclinic felspars show no twinning in thin sections, and consequently a separation of the felspars by means of a dense solution, and a chemical examination, would be necessary to determine with any degree of certainty whether these grains consist of a monoclinic or triclinic felspar.

Unfortunately there was no opportunity in the present instance to make the necessary separation, but a careful examination of typical specimens from the region is purposed with a view to the determination of the occurring felspars.

Hornblende Granite Gneiss, containing hypersthene and some biotite.

—On road, east side Jacques Cartier River, $2\frac{1}{2}$ miles N. of Valcartier.
See Div. V., p. 18.

A rather coarse-grained indistinctly gneissic rock, which in thin sections is seen to be composed of the following minerals as essential constituents: Orthoclase, quartz, plagioclase, hornblende, a rhombic pyroxene, and biotite. Accessory minerals present are magnetite, zircon, apatite, and pleonaste (?).

That the rock has been submitted to great pressure is shown by the fact that the constituents frequently exhibit uneven extinction and in some cases are broken up into aggregates of smaller grains. Intermingled with these smaller grains, or occurring as borders around portions of the larger ones, are little areas of orthoclase and quartz intimately associated with one another in such a manner as to resemble the struc-

*On the Mineralogical Composition of the normal Mesozoic Diabase upon the Atlantic border. G. W. Hawes. Proceed. U. S. Nat. Mus., 1881, pp. 119-134. Also "On the determination of feldspar in thin sections of rocks," ibid., pp. 134-136.

ture known as *granophyrr*. This may really be a structure produced by the crushing of the rock, owing to the orthoclase being cracked and the cracks infiltrated with quartz. If, however, on further study, it prove to be an original structure, this would indicate that the rock is really a crushed granite.

The orthoclase and quartz occur in irregular shaped clear grains which frequently show uneven extinction, and are sometimes broken up into smaller grains as above mentioned.

The same is true of the plagioclase felspar. It, however, as a general rule, does not show the effects of pressure to such a marked degree. It occurs twinned according to both the albite and pericline laws, the lamellæ being frequently bent and the twinning itself probably in many cases induced by pressure.

The hornblende is strongly pleochroic in green and yellow tints, exhibits good cleavages and the ordinary optical properties characteristic of that species.

A considerable amount of pyroxene, sometimes showing a decided pleochroism, is present in the sections. This has, in the two sections which have been made of this rock, invariably a parallel extinction, and is in all probability a rhombic pyroxene allied to hypersthene. It is sometimes found partially decomposed to a substance resembling serpentine.

Associated with the hornblende is a small amount of biotite in irregular shaped individuals.

The iron ore, which occurs in a few black opaque grains, is strongly magnetic and is therefore magnetite.

The zircon occurs in considerable quantity in the form of short, stout, crystals with the usual very strong double refraction, or in rounded crystalline grains.

Apatite is also found in considerable abundance in similar stout crystals.

The mineral referred to as pleonaste, only three individuals of which were found in the two sections examined, occurs in the shape of small rounded, isotropic grains, of a pale yellowish-green colour with a rather high index of refraction and showing no cleavage. No axial figure could be detected in convergent light. Its characters approach more closely to that variety of spinel known as pleonaste, than to any other mineral which commonly occurs as a rock constituent. The dull brown colour of the rock is seen in a thin section to be apparently due to the serpentine-like decomposition product of the rhombic pyroxene, which spreads all through the rock in a network of minute fissures between, and traversing the grains.

Mica Diorite Gneiss.—Road west side Sault à la Puce River, at bridge crossing west branch, three miles north of Château Richer.

This rock, which is medium-grained and greatly decomposed, consists, in the section examined, almost entirely of plagioclase felspar. Some bisilicates were originally present in the rock, but these are now so decomposed to a chlorite that it is impossible in all cases to state what the original minerals were. A small amount of biotite still remains unaltered, but it is possible that some of the chlorite was derived from hornblende. A considerable amount of ilmenite, for the most part altered to leucoxene, together with a few slender crystals and irregular fragments of a mineral having the optical characters of apatite, are also present.

The rock has evidently been much crushed. The larger individuals of plagioclase are seen to be separated by a mosaic of smaller grains, which, in most cases at least, have clearly been derived from the breaking up of larger grains. The twinning lamellæ of the plagioclase are also bent, the mineral shows an uneven extinction and is filled with little hair-like inclusions. A brown decomposition product is present in abundance, filling the minute fissures in the minerals, as in the case of the hornblende granite gneiss from the east side of the Jacques Cartier River.*

The chlorite resulting from the decomposition of the bisilicates is of two kinds, one of which, of a light green colour, corresponds to the normal variety usually observed. The other is of a yellowish-brown colour, has a somewhat stronger double refraction, and occurs in little spherulitic aggregates, which, between crossed Nichols, show the usual dark cross.

Mica Diorite Gneiss.—Road up Sault à la Puce River, three miles north of Château Richer.

This is essentially the same rock as the foregoing one, but contains a somewhat larger amount of orthoclase, and does not show cataclastic structure to such a marked degree.

No. 1. Anorthosite.—Lots 13 and 14, N.W. range of Bras, Sault à la Puce.

A fine-grained light greenish-grey rock, consisting very largely of plagioclase, although some untwinned grains of felspar are present which may possibly be monoclinic.† Evidences of pressure are seen

*See p. 74 L.

†See Introductory Remarks.

in the bending of the twinning lamellæ and in the cracking and breaking of the larger grains. The section affords a good example of Torneböhlm's "mortar-structure" which is characterized by grains of felspar and quartz cemented by a fine mortar of the same materials.* Little patches of serpentine are seen in the section, resulting from the decomposition of some bisilicate, with which biotite is intimately associated. A considerable quantity of an opaque iron ore, probably ilmenite, is present, some of the grains exhibiting sharp crystal outlines. Numerous irregular grains and crystals of apatite were also observed. A very few grains of quartz occur in the section. Mr. Low states that he observed large, apparently untwinned, felspar crystals, porphyritically developed in this rock, but none are visible in the hand-specimen examined.

No. 2. Anorthosite.—Lot 18, S.W. range, Sault à la Puce, one mile further northward up the path from locality of No. 1, near the northern boundary of the anorthosite area.

This, in the hand specimen, is seen to be a rather fine-grained light yellowish-grey felspathic rock, containing only a very small proportion of bisilicates and a little iron ore. It weathers to a rusty brown colour. Mr. Low, in his notes, remarks that this is the same rock as No. 1, occurring in large loose angular fragments. Under the microscope it is seen to be composed very largely of plagioclase felspar, the extinction angle of which (measured on P) was found by several determinations to be about 8° , which would bring it under the labradorite group of the plagioclase series.† The usual evidences of pressure are seen in the section, which presents the appearance of a fine-grained mosaic of felspar through which a few larger grains are scattered. The bisilicates originally present are now almost entirely altered to a serpentine-like substance. A little biotite is present, also apatite and ilmenite.

No. 3. Anorthosite.—Lot 13, N. E. range, Sault à la Puce.

The rock is light greenish-yellow in colour and consists very largely of plagioclase, nearly all well twinned and finely granulated. A few large, twisted and broken, felspar individuals of a violet tinge lie in this granulated material. Lenticular patches of biotite occur in the hand specimen, and a few minute fragments of hornblende and apatite

*Geol. Fören. Förhandl., 1881, V., p. 233.

†Cf. Max Schuster, "Ueber die Optische Orientirung der Plagioklase." T.M.P. M. 1880, III., 117-284.

were observed in the thin section examined. Ilmenite, in small grains, is also distributed through the rock. A single grain of what is apparently quartz was detected in the fine-grained portion of the rock, but the axial figure obtained was not satisfactory enough to determine it with certainty. In his field notes Mr. Low regards this as the same rock as Nos. 1 and 2. Dr. Adams examined a fragment of this specimen, which, however, showed no coloured constituent, with the exception of a few small grains of iron ore.

No. 4. Anorthosite.—Lot 8, S. W. range, Sault à la Puce.

Essentially the same rock as No. 2, but the specimen is darker in colour, with patches of a reddish-violet tinge in it, is somewhat coarser-grained, and the thin section examined shows a larger proportion of coloured constituents, although these are far from being abundant. Torneböhni's "mortar-structure" is well shown in this rock, as in No. 2. The plagioclase is full of microlites, and in several grains beautiful examples of pressure twinning and zonal structure are seen. The bisilicates are much decomposed, in some cases entirely so, chlorite and hematite filling the spaces. Biotite appears to be the most abundant coloured constituent. Little hexagonal scales of hematite occur in the felspar, and there are also a few crystals and irregular grains of apatite distributed through the section. Ilmenite is also present in small veins and isolated grains and crystals.

NOTE.—Nos. 5 to 15 form a continuous section, going south along the road on west side of Sault à la Puce River in the Parish of Château Richer.

No. 5. Anorthosite.—Lots 63 and 64, Château Richer.

This is a fine-grained, greyish, almost purely felspathic rock, indistinctly foliated, and having larger felspar individuals disseminated through it giving to it a somewhat porphyritic appearance.

The plagioclase shows excellent cataclastic structure and perfect granulation. A few small grains of iron ore are scattered through it, and a very minute quantity of biotite and chloritic material is present.

No. 5a. Norite.—Same locality as No. 5, with which it is closely associated.

A rather fine-grained rock, with a few plagioclase crystals porphyritically developed. It weathers to a brownish-white colour. Consists of plagioclase, an untwinned felspar, hypersthene, biotite, a very small quantity of hornblende and a little iron ore probably ilmenite, and

apatite. The plagioclase presents no unusual features. The hypersthene is strongly pleochroic, in light green and pink shades. It is much cracked, the cracks being filled with a serpentinous decomposition product which also spreads all through the rock in a network of minute fissures between, and traversing the grains.

No. 6. Anorthosite.—100 yards S. of locality of Nos. 5 and 5a.

A fine-grained pink and green felspathic rock with gneissic structure. Under the microscope it is seen to consist very largely of plagioclase, well-twinned, but not very fresh in the specimen examined. A little biotite also occurs, but is much altered. Ilmenite is rather abundant, in grains surrounded by a dull decomposition product of some kind which does not present the usual characters of leucoxene. Apatite in rounded grains is tolerably plentiful throughout the section

No. 7. Mica Diorite Gneiss, containing some quartz.—At first forks of road up Sault à la Puce River.

In the hand specimen it presents the appearance of a coarse-grained rock which is much weathered and rusty. It consists of plagioclase, quartz, and a considerable quantity of biotite. The plagioclase is all in rather large grains, with not much crushed material between them, and is well-twinned. The quartz occurs as a few grains scattered amongst the felspar. The biotite is dark brown in colour, strongly pleochroic, and in many instances shows a partial or complete alteration to chlorite. A few grains of apatite and a little iron ore were observed.

No. 8. Biotite Norite Gneiss.—Lot 65, Château Richer.

Mr. Low states that there is some uncertainty as to whether the rock from which this specimen was taken is *in situ* at the locality. It is a rather coarse-grained, dark greenish, rusty-weathering rock with minute particles of iron pyrite distributed through it. Gneissic structure is shown in the mass. It consists of plagioclase, hypersthene, biotite, some quartz, a large amount of apatite, and a little ilmenite and iron pyrite. The plagioclase exhibits the usual effects of pressure and is finely granulated. The hypersthene is almost entirely altered to serpentine, and the biotite in many instances to chlorite. A few grains of quartz were observed in the section examined. Apatite full of inclusions is exceedingly abundant, occurring in large irregular grains.

No. 9. Granite Gneiss.—A short distance S. of No. 8.

A greenish-grey rusty-weathering rock consisting of quartz, felspar (orthoclase and plagioclase), and a small quantity of biotite and iron

pyrite. The quartz and felspar occur in large irregular grains distributed through a fine-grained mosaic derived from the crushing and breaking up of the same materials. Secondary granophyr structure is well developed in the section. The felspar is mainly untwinned (orthoclase); plagioclase, although present, being not at all abundant. The structure of the rock is granitic and it bears evidence of having been greatly crushed. A large quantity of magnetite, some iron pyrite and a little apatite are present. Decomposition products spread all through the rock, giving it a rusty appearance.* Chlorite also occurs, apparently derived from the decomposition of grains of hornblende or biotite.

No. 11. Anorthosite.—Lot 68, Château Richer.

This is an almost exclusively felspathic rock of a light greenish-grey colour tinged with light violet. Scarcely a trace of any bisilicates are discernible in the specimen furnished me. The greater proportion of the felspar grains, if not all, consist of plagioclase. Some show no twinning. The felspar occurs in layers of larger grains, with granulated felspar between them, giving to the section a banded appearance.

Some of the larger grains are much twisted and broken, and granophytic structure is developed throughout the section. A very few traces of what were once bisilicates were observed, but they are now entirely altered to chlorite, hematite, &c. Some few small clear grains of quartz were observed amongst the crushed plagioclase. Apatite is present in rather large irregular grains, also in coarse crystals. Pyrite, much decomposed to hematite, is tolerably abundant, the hematite in places giving a reddish tinge to the hand specimen. Dr. Adams examined a section from this rock and has kindly allowed me to consult his notes on it. The rock is a good example of the anorthosite division of the gabbro family, as proposed by him.

No. 12. Mica Diorite Gneiss.—Lot 70, Château Richer.

A rather fine-grained, dark green, rusty-weathering, gneissic rock, consisting of plagioclase, biotite, hornblende, hypersthene (?) and quartz, with some ilmenite accompanied by leucoxene, and apatite. The plagioclase for the most part is finely granulated, well twinned, possesses uneven extinction, and is much bent and broken. A few large grains remain scattered through the finer material. Of the bisilicates, biotite is the most abundant, but presents no unusual features. Small patches of it are scattered through the hand specimen. All the bisilicates are more or less decomposed, especially the hornblende, which is altered

*Compare No. 5a., also *Hornblende Granite Gneiss*, p. 74 L.

to serpentine and carbonates. The serpentine has a well developed spherulitic structure. A few grains of what was perhaps hypersthene were observed, but they are so badly decomposed that a satisfactory determination is impossible. Apatite is very abundant in groups and strings of large irregular grains, and a few large well-defined crystals were also seen. A little quartz and some ilmenite are present, the latter associated with leucoxene.

No. 14. Anorthosite.—Lot 71, Château Richer.

The section examined is characterized by an almost total absence of coloured constituents, the rock being composed for the most part of plagioclase felspar, although a few untwinned grains occur. In the hand specimen a few irregular patches of biotite were observed, also one or two grains of pyrrhotite and a little ilmenite. The felspar shows evidences of pressure and some fine examples of pressure twinning were seen.

No. 14a. Pyroxene Granite Gneiss.—Lot 71, Château Richer.

This and the preceding rock are intimately associated at the locality. It is a very basic gneissic rock, composed of orthoclase, plagioclase, pyroxene and quartz, with apatite and an iron ore, probably magnetite. It is granitic in structure, medium-grained, and of a dark greenish-grey colour, with parallel bands of the dark green pyroxene running through it, giving a decidedly gneissic character to the mass. The pyroxene is very abundant, of a dark green colour and quite fresh. Its pleochroism is small, green to yellowish-green. The mineral occurs mostly in irregular grains, although in a few instances it shows tolerably regular crystal outlines, and is intimately associated with the magnetite and apatite. Twinning parallel to (100) was noticed in a few grains. The apatite and iron ore are abundant, the former occurring in large crystals and rounded grains. Quartz is not very abundant in the section. A curious coarse granophyr-like structure is noticeable in this rock.

No. 15. Pyroxene Granite Gneiss.—Lot 72, Château Richer.

This section, in general, resembles No. 14a, but contains less plagioclase and more quartz, and holds, besides, much titanite.

No. 20. Anorthosite.—Front of 2nd range, Ste. Anne, on road in rear of church, 200 yards from contact.

Another of the fine-grained plagioclase rocks in which bisilicates are almost entirely wanting. A few grains of pyrite are visible in the

hand specimen. Under the microscope the even granulation of the plagioclase is well brought out. A very small quantity of quartz is present, also a little ilmenite accompanied by its alteration product leucoxene, and a few large irregular grains and crystals of apatite. Traces of what were originally bisilicates are to be seen, but almost entirely altered to chlorite, &c. Judging from the outlines of some of the grains they may have been originally diallage.

No. 21. Gabbro Gneiss.—Front of 2nd range, Ste. Anne, on road in rear of church, about 10 yards from contact.

A rather coarse-grained rock, which, under the microscope, is seen to consist of plagioclase, a monoclinic pyroxene, biotite and hornblende, with ilmenite and apatite. The granulation of the plagioclase is very perfect. In the hand specimen numerous small plates of a red felspar occur, together with some good-sized masses of pyroxene and ilmenite, scattered through the finer-grained, greenish-white, felspathic ground-mass, giving the rock a porphyritic appearance. The pyroxene is light green and much decomposed to a fibrous yellowish-green chloritic substance, alteration proceeding along the cleavage. It has a large extinction angle and is associated with a small amount of hornblende. Ilmenite, accompanied by a little leucoxene, is rather plentiful in this section. Dr. Adams examined this rock, but observed nothing in addition to what was shown in my section. Lenticular bands of a dark green granular pyroxene, or cocolite, were observed by Mr. Low at the junction of this rock with the gneiss, sometimes interfoliated with the anorthosite rocks and again between bands of gneiss at, or near, the contact.

No. 23. Pyroxene Granite Gneiss.—Following No. 21.

A rather fine-grained, much decomposed, rusty rock, possessing distinct gneissic structure and containing much magnetite arranged in parallel bands. Under the microscope it is seen to be composed of a fine-grained mosaic of felspar and quartz, through which larger individuals are distributed of felspar, also pyroxene, hypersthene, hornblende, a little biotite, apatite and magnetite. The felspar is largely untwinned, and exhibits good examples of "schillerization."* Both monoclinic and orthorhombic pyroxene are present; the former shows the same features as in section No. 21. The latter is strongly pleochroic in pink and light green tints and has a parallel extinction. It is in all probability hypersthene. The other constituents present no unusual features. Hornblende and biotite are not abundant. Apatite and magnetite are plentifully distributed throughout the section.

* J. W. Judd, Quart. Journ. Geol. Soc. Lond., XLI., 1885, p. 383.

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON

PORTIONS OF THE PROVINCE OF QUEBEC

AND ADJOINING AREAS IN

NEW BRUNSWICK AND MAINE

RELATING MORE ESPECIALLY TO THE

COUNTIES OF TEMISCOUATA AND RIMOUSKI, P.Q.

BY

L. W. BAILEY, PH.D., F.R.S.C.

AND

W. McINNES, B.A., F.G.S.A.



OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY

1893

A. R. C. SELWYN, C.M.G., LL.D., F.R.S., &c.,
Director of the Geological Survey.

SIR,—I have the honour to submit the following report of observations and explorations made by myself and Mr. W. McInnes, with the assistance of Mr. J. W. Bailey, in portions of the province of Quebec and adjacent areas in Maine and New Brunswick, chiefly during the summers of 1887 and 1888.

The report is accompanied by a quarter-sheet map, representing portions of Temiscouata and Rimouski counties, being continuous on the one hand with the series already issued of the adjoining portions of the province of New Brunswick, and on the other with those prepared by Dr. R. W. Ells in illustration of the geology of the Gaspé peninsula.

I have the honour to be, sir,
Your obedient servant,
L. W. BAILEY.

FREDERICTON, 25th November, 1890.

REPORT
ON
PORTIONS OF THE PROVINCE OF QUEBEC
AND ADJOINING AREAS IN
NEW BRUNSWICK AND MAINE
RELATING MORE ESPECIALLY TO THE
COUNTIES OF TEMISCOUATA AND RIMOUSKI, P.Q.
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The rocks to which this report relates are a portion of those Previous reports. which have been commonly known as the Quebec group. As is well known, the latter have been the subject of much previous investigation, both by the officers of the Geological Survey and others, numerous reports and memoirs having been at various times published concerning them. The most recent of these, upon the part of the Geological Survey, are those of Dr. R. W. Ells, who in Vols. II. and III., New Series of the Survey publications, has given not only a full historical summary of the progress of the investigation, but from a minute study of the rocks in the vicinity of Quebec, supplemented by explorations extending from the Vermont boundary to the extremity of the Gaspé peninsula, has brought forward data, both of a stratigraphical and palaeontological character, which, while in important particulars at variance with views previously announced, seem to place the main facts of the case beyond further controversy.

The most important of the conclusions thus arrived at, so far as Dr. Ells's conclusions. they bear upon the region to be considered in the present report, may be briefly stated as follows:—

(1.) The larger part, if not the whole, of what was at one time known as the "altered Quebec group," is now regarded as a portion of an older and independent series of Pre-Cambrian age.

Lévis.

(2.) Of the two main groups into which the so-called Quebec group was originally divided, viz., the Sillery and Lévis (the division known as the "Lauzon" having been subsequently introduced and then abandoned), the latter or Lévis section, which up to 1888 was regarded as the older of the two, is now considered to be the more recent, the name "Lévis" being, however, restricted to the group of blackish green and gray shales which, as seen at Lévis and St. Joseph, contain characteristic graptolites of Calciferous-Chazy age, together with the associated limestones and limestone-conglomerates—the matrix of the latter also carrying typical fossils of the Calciferous formation, while the inclosed pebbles are wholly of Cambrian or Potsdam age.

Citadel rocks.

(3.) That a portion of the rocks forming the bluffs underlying the city of Quebec, as well as a portion of the Island of Orleans, and designated as the "Citadel rocks," which were at one time regarded as forming a portion of the Lévis group, are, as shown by their fossils, distinct from and more recent than the latter.

Sillery.

(4.) That the rocks of the "Sillery" formation, as thus understood and limited, contain a fauna corresponding to that of the Upper Cambrian series, its upper beds perhaps merging into those of the Lévis group, which is referred to the Lower Ordovician or Cambro-Silurian system, while at its base, and representing the Lower-Cambrian, is a series of beds in which, as yet, no fossils have been found. The Quebec citadel rocks have also been referred to the Cambro-Silurian or Ordovician system, and carry a fauna which is distinctly of Trenton-Utica aspect, and is followed upwards by fossiliferous Utica and Hudson River shales.

Potsdam.

To the above it may be added that the separation of a portion of the rocks about Quebec, as well as eastward along the Lower St. Lawrence, under the designation of "Potsdam," and its subdivision into three sections, as proposed and mapped by Mr. Richardson, is untenable, the fossils upon which this arrangement was based having been found to occur only in the pebbles of the conglomerates from which they were obtained, and not in the rock itself.

In describing the region examined by us we shall assume that these conclusions are correct, nothing having been observed by us which is in conflict with them, while they seem to afford the most satisfactory explanation of such facts as we have observed.

Region described.

The region referred to, represented in accompanying maps, lies almost wholly in the province of Quebec, having as its central and chief portion the county of Temiscouata, but including also a small part of Rimouski county, as well as portions of the counties of Madawaska and Restigouche, in the province of New Brunswick. Sheet No. 18 S.E.

lies immediately north of sheet No. 17 N.E. of the series of New Brunswick maps, and in turn is followed north by sheet No. 18 N.E. embracing chiefly the region drained by the Rimouski and Metis rivers, while sheet No. 18 S.W. embraces a similar small area about Rivière du Loup. The area thus indicated, and to be presently described, is on the eastern side continuous with that described and mapped by Dr. R. W. Ells about the headwaters of the Restigouche and Metapedia rivers (No. 3 S.W. Quebec maps); and on the west adjoins the areas in Kamouraska county, described but not yet mapped by the same author. On the north side the several sheets terminate, so far as our investigations are concerned, with the south shore of the St. Lawrence River, between Rivière du Loup and Little Metis. The rock formations included within the area above defined are, as far as known, but two in number, viz., the Silurian and the Cambrian, with possibly small unrecognized areas of Cambro-Silurian or Ordovician.

Boundaries of
accompanying
maps.

SILURIAN.

The rocks of this system, as found within the areas here considered, have been quite fully described in previous reports, their stratigraphy, fossils and correlations with other Silurian districts, especially in New Brunswick, Maine and Nova Scotia, having been stated in considerable detail. We have no further information concerning them, so far as they occur within the area now under discussion, but a question having arisen as to their western extension and their separation from older and lithologically similar strata about the sources of the St. John River, some particulars may here be given of an exploration of the latter having in view the more exact determination of these points.

As represented upon Lake Temiscouata the portion of the Silurian system which immediately adjoins and overlaps the Cambrian strata to be presently described, does not represent the lowest member of that system, being composed of white sandstones and overlying calcareous rocks, of which the fossils indicate an age ranging from the lower to the upper part of the Lower Helderberg horizon, while at a short distance south are heavy conglomerates followed by hard sandstones and shales containing fossils chiefly of the Niagara formation. The larger part of these beds occur only upon the eastern side of the lake, where the calcareous strata form the prominent eminence known as Mt. Wissick; but upon the western side, the only fossiliferous strata observed are a few shales, imperfectly exposed about a mile northward from the village of Cabano. The older conglomerates and sandstones of the Niagara group are, however, well exposed here and may be followed

Lake Temis-
couata.

westerly for several miles along the road leading to the mills on the Silurian slates. Cabano River. Immediately to the south of the above undoubted Silurian strata is found the great series of slates first described in the Geology of Canada in connection with the Gaspé series, and which has since been found to spread so widely over the northern portions of New Brunswick, as well as adjacent areas in Quebec and Maine. These slates, as seen along the lower half of Temiscouata Lake and on the Madawaska River, are of gray, bluish-gray and dark gray, rarely black colours, often weathering to a dull olive-green, very fine grained but including harder bands, and generally more or less calcareous. They are throughout characterized by numerous and often intricate contortions and these, with a strongly developed slaty cleavage, make any attempt to determine their thickness or relations well nigh hopeless. Neither on the Lake nor on the Madawaska have they been found to contain any fossils, these having probably been obliterated by molecular movements; but the occurrence of fossils at many different points in the resembling strata which spread so widely to the east and south, and all of which indicate a Silurian horizon, seem to justify the position first assigned them as also Silurian, and as the equivalent of the upper part of the Gaspé series. In ascending the River St. John from Edmundston, slates which are evidently the same as those of the Madawaska and Lake Temiscouata are frequently exposed upon its banks as far as the mouth of the St. Francis River. They exhibit the same alternations of fine and soft with somewhat harder, sandy beds, have the same greenish, somewhat chloritic aspect, and the same strong and nearly vertical cleavage. The dips, when recognizable, are usually low, and indicate a series of broad and open undulations. Two miles above Edmundston the dips are north-easterly, at angles of 30° ; at Mecham's Rapids, six miles above, the inclination of the beds is N. 10° E. $< 40^{\circ}$; about ten miles up it is S. 30° E. $< 30^{\circ}$; and about half a mile below Baker River, where the beds are finely exposed, it is about N. 80° E. $< 15^{\circ}$. At the Narrows, about five miles above Fort Kent, the slates, here finely banded, dip S. 40° E. $< 85^{\circ}$, a dip which is repeated, or nearly so, two miles further up. At Connors's Landing, ten miles above Fort Kent, the dip is N. 20° E. $< 70^{\circ}$.

Upper St.
John River.

St. Francis
River.

On the St. Francis River the exposures are but few, but such as occur are quite similar to those on the main St. John, and have similar low inclinations, mostly to the southward, and the same peculiar greenish tint. No trace either of the limestones or the conglomerates of Lake Temiscouata could be found on this stream, but blocks of whitish-weathering sandstone, similar to those found at the base of Mount Wissick, which occur a little below the foot of Pohenegamook,

or Boundary Lake, appear to indicate that the northern boundary of Pohenega-mook Lake.
the Silurian is not far from this place. In the map of Mr. Richardson,
the country on either side of the lake to its head is represented as
Silurian, but the earlier description given in the Geology of Canada,
1863, is, without doubt, the correct one ; the only strata visible being
hard glossy slates of the Cambrian system. Above the St. Francis, Description of
the main river lies wholly in American territory, and presents much
the same aspect as in the portion already described, the bluish, greenish-
weathering slates showing frequent outcrops, which are often charac-
terized by short and sharp foldings of the strata, the latter being, at
the same time, cut by strong and highly inclined cleavage planes. The
scenery of this portion of the St. John is very striking, the bordering
hills, which are quite high, sometimes exhibiting strongly serrated
outlines, while between them and the river are belts of terraced flats
and intervale, most of which are cultivated. Access to the upper
farms is, however, difficult, there being no roads whatever, while com-
munication by water, effected in summer by canoes or tow-boats, and
in the winter on the ice, is impeded by the numerous and sometimes
dangerous rapids. These are, in some instances, due to ledges, but not
unfrequently also to accumulations of boulders, which cross the river
in trains, and by their grouping and character, suggest that they are
of morainic origin.

Ascending the Little Black River, which joins the St. John about Little Black
River.
twenty miles above the mouth of the St. Francis, only one exposure, of
blue slates, was observed in the first eight miles, the stream being
exceedingly tortuous, and bordered either by extensive low flats or by
banks of stratified clay or gravel. In some places the clays have an
observed thickness of ten or twelve feet, and are covered by thirty or
forty feet of sand, with from three to four feet of coarse gravel between
the two. About twelve miles up, the still-waters cease, and about
fifteen miles up, occurs strata, which, probably, mark the limit of
the Silurian in this direction. They occur about the junction with the
north-east branch, and consist, in part, of black slates, which are
somewhat graphitic, and with which are associated purplish-gray, red-
weathering slates, and partly of a hard gray grit and conglomerate,
containing pebbles of black slate and white quartz. Their dip is S.
 40° E. < 60 . These were at first believed to belong to, and represent
the base of, the Silurian system, but comparisons since made, lead us
to think that they belong rather to the Cambrian system, of which
undoubted strata occur a short distance farther up the stream.

Between Little and Big Black rivers, upon the main St. John, gray,
bluish and greenish-weathering argillites, continue to be the only rocks

Geology of
Upper St.
John.

seen *in situ*, though boulders of metamorphic rocks, including hard sandstones, red slates and conglomerates, become abundant, and by their accumulation at certain points, cause long and dangerous rapids. In the report of the Geological Survey of Maine, and in an accompanying map, all this portion of the valley of the river, and for many miles above it, is represented as composed of talcose schists, but we looked in vain for anything to which that name could fairly be applied. Some of the slates found here are glossy, and, perhaps, a little unctuous, and they often contain scattered scales of mica, but to no greater extent than do many of the slates on Lake Temiscouata and in northern New Brunswick, which are certainly nothing more than ordinary argillites. They exhibit also the same greenish-chloritic aspect, becoming brownish-red under the influence of water, already noted as characterizing the slates to the eastward. The best exposures are at Big Black Rapids, and outcrops occur at intervals from this point to Hunter's, ten miles below the Seven Islands. Their strike is almost uniformly S. W., and the dip north-westerly, at high angles. The land on either side of the river is here much lower than further down the stream, the hills being few and of slight elevation; while the stream itself, though broad, is much encumbered with boulders, which, as below, appear to cross its course in trains, and are the cause of numerous and difficult rapids.

Settlement at
Seven Islands.

From Hunter's to the Seven Islands, the navigation is easier, with more still-water and fewer ledges and boulders, while at the "Islands," the stream divides into numerous channels, intersecting an extensive alluvial flat, which, although almost entirely isolated from communication with the outside world, has, for many years, been the seat of a small but very prosperous farming community. The ordinary means of access to the settlement is by a very rough and often almost impassable winter-road from St. Pamphile, in Quebec, a distance of about fourteen miles; but, understanding that this road showed little or nothing of the underlying rocks, our exploratory route was chosen by way of the Big Black River, which, passing near St. Pamphile, joins the St. John, fifteen miles below the Seven Islands. Reaching St. Pamphile by the Elgin Road, the rocks of this settlement were found to be hard dark gray grits, interstratified with black slates, probably belonging to the Sillery division of the Cambrian system, and the extension of those seen on the Little Black River. Two miles west of St. Pamphile church, they form a high hill on the road to Seven Islands, but are here much coarser, becoming a somewhat schistose conglomerate, holding pebbles up to a foot in diameter, chiefly of black quartzite, with included beds, usually thin, of very lustrous black slate, the conglomerate being much veined with white quartz. Their dip is N. 15° W. < 75°—80°. The

Conglomerate.

finer beds are quite similar to some to be hereafter noticed as occurring along the line of the Temiscouata Railway at St. Louis de Ha' Ha', and are certainly Lower rather than Upper Silurian, as represented in the map of Mr. Richardson. Conglomerates and slates, similar to the Big Black River. above, are again seen on Big Black River, where this is crossed by the Seven Islands road, and for a quarter of a mile below. About half a mile north of the boundary, these are followed by other slates of dark gray colour and weathering bluish, which are also well exposed directly on the boundary, showing a regular and distinct dip N. $< 80^{\circ}$ — 90° . These slates are without conglomerates, are even-bedded and fissile, with thin layers of sandstone, and might readily be taken for Silurian strata; but, after prolonged search, we failed to find any fossils in them, and are, therefore, uncertain whether they should be referred to this or to some older horizon.

The difficulty here referred to of distinguishing between Silurian and older rocks in this section, and which was the main object of its exploration, is the same as that found in the Eastern Townships, and which originally led in that section to the reference of large areas, including important gold bearing districts, to the Silurian, whereas, as has been shown by Dr. Ells, these are largely, if not wholly, of Cambro-Silurian and Cambrian age. In our further exploration of the Upper Route St. John, having this separation in view, the route followed was by way of the Big Black to its junction with the St. John, the ascent of the latter to the Seven Islands and beyond to the Forks, the ascent from this point of the South-west Branch for twenty-five miles to Baker Lake, and after returning to the Forks, a similar ascent of the Northwest Branch, whence, by way of its main tributary, the Daaquam, access was had to the settlement of St. Magloire in Quebec.

The Big Black River, south of the boundary, shows but few exposures, such as occur being of slates, apparently of Silurian age. The rocks occurring between the mouth of this stream and the Seven Islands have already been described. Two miles above the Islands, gray, bluish-weathering and somewhat sandy slates occur, with a south-west strike and nearly vertical dip, and thence follow the course of the river for several miles, forming low bluffs upon its shores. Six miles above the Islands the slates are more micaceous than below, though never assuming the aspect of true mica-schists. Their dip here is S. 5° E. $< 70^{\circ}$. Ten miles above the Islands alternating slates and fine sandstones, here only slightly micaceous, dip S. 25° E. $< 70^{\circ}$. Passing Burnt Land Brook, which is eighteen miles above Seven Islands, the land becomes low and the ledges fewer, but such as occur present no noticeable difference as compared with those seen lower

down, except perhaps in the fact of their frequently holding white quartz veins. Five miles below the Forks the right bank shows ledges of hard, gray, micaceous sandstones, alternating with fine, fissile, dark-gray slates, and having a regular dip S. 12° E. $< 80^{\circ}$. Approaching the Forks the stream becomes more rapid, and is filled with large boulders, one of them thirty feet long by thirty feet high, of greenish serpentinic rock, with others of conglomerate and hard sandstone. Above the Forks, on the South-west Branch, the stream for several miles shows only dead-water, and no exposures occur as far as the mouth of Baker Brook. On this latter stream an exposure is found three miles up, of bluish-gray slates and sandstones of the ordinary Silurian type, dipping S. 25° E. $< 80^{\circ}$, but with this exception no rocks *in situ* are visible as far as the outlet of Baker Lake, the limit of our exploration in this direction.

N. W. Branch
St. John
River.

Fossils.

Earlier exam-
ination.

Returning from Baker Lake to the mouth of the North-west Branch, the latter was then ascended, with the opportune aid of heavy rains, to its forks or point of confluence with the Rivière Noire, a small stream flowing south from Lac de la Frontière. This stream we ascended, but with great difficulty, to a point about one mile below its first falls, and three below the lake and boundary. Here occur good exposures of fine-grained, gray sandstones, slightly micaceous and alternating with slates, and in these were found the only fossils met with in any portion of this region. These consist of long, coarsely and longitudinally furrowed stems of plants ; but though occurring in considerable numbers they are not sufficiently preserved, or of such a character as to throw much light upon the age of the containing beds. These strata have a distinct and regular dip S. 10° E. $< 80^{\circ}$, and their general aspect is not unlike that of many Silurian beds, but in view of the observations made by others in this vicinity (See Report for 1887, part K, page 13) we are not prepared to say that they may not be older. In an examination of this region made by Mr. A. Webster, formerly of the staff of the Geological Survey, and referred to in the report last cited, similar slates and sandstones are described as having associated with them beds of dark gray graphitic limestone, but these are situated somewhat nearer to Lac de la Frontière, and owing to want of water, were not reached by us. The whole series is regarded by Dr. Ells as Cambro-Silurian. On the Daaquam, as far as ascended, viz., to a point where this is touched by the clearings eight miles south-west of St. Magloire, no exposures of any kind were observed.

It will appear from the above observations that so far as the main issue is concerned, viz., the separation of the Silurian and older strata,

these show nothing of a decisive character by which the question may be determined. Admitting that the beds observed upon the Rivière Noire, and possibly those near the boundary upon the Big Black River, are older than Silurian, though the character of the plant remains upon the former is rather unfavourable to this view, we cannot but think that the exposures in the main valley of the St. John, and as far up as Baker Brook, are of Silurian age. At least they do not differ essentially in character from those which occur so widely lower down in the same valley, and which all the facts in our possession tend to refer to that horizon. It may here be observed that the character and relations of these latter rocks are strongly marked in the physical features of the region, as strikingly seen in ascending from the valley of the Daaquam to the settlements south-west of St. Magloire. The land here rises rapidly and from a high hill, two miles and a half from the river, one may look back over the valley and for many miles follow its course north-easterly and south-westerly as a low tract of nearly level land, along the southern side of which, at a distance of ten or fifteen miles, is another chain of somewhat prominent hills, probably the westward extension of the Aroostook Mts. from the sources of the Alleguash River. It may be added that as a matter of practical cartography the question, so far as Canada is concerned, is, after all, of little importance, as it is probable that the Silurian rocks, if such they are, are almost wholly confined to the region south of the Canadian boundary.

General conclusions.
Aroostook Mtns.

CAMBRO-SILURIAN.

According to the arrangement of Dr. Ells, referred to in the introduction, and which has been here adopted, the rocks regarded as Cambro-Silurian embrace (1) those which, as best exhibited in the vicinity of Point Lévis, consist of blackish green and gray shales, carrying a characteristic Ordovician fauna, with which are associated dolomitic limestones and limestone conglomerates, the whole described as resting in synclinals of the underlying Sillery or Cambrian formation ; and (2) the overlying black bituminous shales and limestones, including the rocks of the Citadel of Quebec, which carry faunas ranging from the Trenton, through the Utica formation, to the age of the Hudson River or Lorraine shales.

Description of rocks of Cambro-Silurian age.

Of these several groups of rocks we are unable to say with certainty that any occur within the district to which this report relates. As regards the fossiliferous limestones and shales, however, of the Trenton-Utica formation, which are so conspicuously developed upon the north shore of the St. Lawrence at Montmorenci and elsewhere, it may be

Trenton-
Utica pro-
bably absent.

considered as quite certain that nothing resembling these is to be met with on the south shore, at least within the settled portions of the area examined by us. The fact, however, that such strata do occur, only a few miles farther east on the Gaspé shore, near the mouth of the Tartigo River (see Report of 1880-81-82, page 30 *dd*) where they are infolded among the Cambrian strata, would make us hesitate to say that such beds, similarly infolded, may not occur over the large and to a great extent uncleared tract embraced in this report. It may, however, be observed that these rocks, whose nature, when present, is so readily recognized, are equally absent from the drift, a circumstance which renders the fact of their occurrence extremely improbable.

Quebec
Citadel rocks.

As regards what has been termed the Quebec Citadel series, also consisting of black bituminous shales and limestones, with some conglomerates, but holding a fauna in some respects distinct from the typical Trenton-Utica formation, we have also failed to recognize its presence over any portion of the area examined by us. The occurrence, however, of some of its peculiar forms in the strata revealed in the valley of the Beccaguimic River in New Brunswick would seem to indicate that the group is more than a local one, and that similar remains may yet be found at some points over the wide area by which these two localities are separated.

Lévis group
nowhere
recognized.

The lowest rocks of the Ordovician or Cambro-Silurian, as here classified, are those of the Lévis group proper. Of their occurrence or absence within the area under discussion, we feel unable to speak with any great degree of confidence, for although particular groups of strata are sometimes there met with, which in lithological aspect might well be compared with the typical beds as seen at Lévis and the south-west end of the Island of Orleans, careful search has as yet failed to reveal any fossils which are sufficient to establish their identity, while the extreme complexity of arrangement, as revealed along the coast, together with the want of good exposures in the interior, make the study of the stratigraphy, and the identification of particular horizons exceedingly difficult. Under these circumstances it only remains for us to describe the various formations of the entire area, as they have been actually observed, which may be most conveniently done in connection with the consideration of the Cambrian system, to which undoubtedly the great bulk of the strata belongs.

CAMBRIAN.

Prior to the publication of the present report, the most important references to the area now to be described are those contained in the "Geology of Canada, 1863," and the subsequent report of Mr. Richard-

son in 1868. In the first of these publications the references are almost entirely confined to the settled areas, immediately adjacent to the St. Lawrence ; but in the latter the various groups distinguished in the vicinity of Quebec are traced eastwardly, and both described and mapped as to their supposed relations along the section afforded by the Temiscouata Portage road. The subdivisions recognized included not only the Sillery, Lauzon and Lévis of the earlier reports, the latter being regarded as the lowest, but also a group referred to the Potsdam, and further subdivided into three divisions. The reasons for this latter view, and for its abandonment by later observers, are fully given in the report of Dr. Ells for 1887-88 (part II., page 42 K), and will be further noticed here.

The Temiscouata section is by far the most complete of any to be found in the district. Indeed, with the exception of that afforded by the Intercolonial Railway between Metapedia Lake and Metis, and that of the Pohenegamook road, it is the only accessible line of traverse across the entire belt of Cambrian rocks in this part of Quebec. While, however, that of the Intercolonial covers a breadth of only about eight or ten miles, that of the Temiscouata road embraces a distance of over forty. The recent opening also of the Temiscouata Railway having afforded, in its cuttings, admirable facilities for the examination of the rocks which it intersects, these have been carefully studied, and will be here made the basis of comparison for the entire region.

The north-eastern part of Lake Temiscouata is occupied by a series of rocks, briefly referred to in the Geology of Canada, 1863, as belonging to the base, *i. e.*, to the "Lévis" division of the Quebec group, as then understood. As seen on the south-east shore of the lake, above Mt. Wissick, they consist of gray and dark gray fissile clay slates, holding thin interlaminated beds, from two to four inches thick, of hard gray sandstone and, at the foot of the eminence named, are (as described in the Report of 1887-88, part II., page 29 M) covered unconformably by the fossiliferous limestones and sandstones of the Silurian system. In these slates, which, in contrast with the rocks of the mountain, are highly tilted and corrugated, we have, during the last summer, succeeded in finding fossils which, for the first time, afford definite evidence as to the age of the beds containing them. These, in addition to obscure Lingulae, include undoubted specimens of *Obarella* (or *Linnarsonia*) *pretiosa*, Billings. As this species is not only characteristic of the Sillery group, as here understood, but confined to it, its occurrence may be regarded as showing the equivalency of these beds to those which on the Chaudière,

Cambrian of
Lake Temis-
couata.

Sillery fossils.

Fibrous lime-stone bands. at St. Michel, on the St. Lawrence, and elsewhere, contain the same form, and which are regarded as representing the upper member of the Cambrian system. Some portions of the slates are banded with numerous thin layers, from one to four inches wide, of light gray, yellowish-weathering limestone, having a peculiar transverse fibrous structure, and from this feature have been compared (Geology of Canada, 1863) with the rocks of the Chatte River, on the north side of the Gaspé peninsula. They are thought by Dr. Ells, who has personally examined them, to probably represent Divisions 2 and 3, of the section given by him as occurring at Cap Rouge, near Quebec.

White sand-stones.

It should be added that in Cabano village, at the foot of the northern section of the lake, and in the line of strike of these beds, is exposed a heavy mass of white vitreous sandstone, which may be a part of the same series. It is, however, completely surrounded by fossiliferous Silurian slates, and it has been found impossible to determine whether it pertains to the older series, protruding through these slates, or is the equivalent of very similar sandstones, which at Mt. Wissick occur near the base of the Silurian.

Flaggy lime-stones.

Strata similar to the above occur for some distance along the south-eastern side of the lake, corresponding approximately to its course, and again upon its north-west side; but here, as seen just above Sandy Point, the included limestones are flaggy, breaking in broad slabs, the fracture of which is conchoidal, while the unequal hardness of the calcareous and slaty layers gives, by weathering, to some of the beds, a gnarled or ribbanded appearance. The dips are irregular, in some places north-westerly, in others south-easterly, at varying angles. It is probable that they occupy the whole of the low ground, a mile or so wide, on the north-west side of the lake, and in their westerly extension underlie the similar low tract crossing the Temiscouata Railway and Portage road, between Cabano and the 37th mile post. Further west, the same beds have been observed on the Cabano River, three miles above its mouth, whence they probably cross to the foot of Boundary or Pohenegamook Lake. In an easterly direction, owing to the uncleared state of the country, it has been impossible to trace them; but it is probable that they are at no great distance overlapped by the Silurian strata which in this direction sweep northwards towards the St. Lawrence.

Plumbaginous slates.

Where the Temiscouata road crosses Little River or Rivière du Lac, near the 38th mile post, are fine, gray and dark gray, somewhat plumbaginous slates, seamed with spar, which probably form a part of the belt last described. Just north of this the land begins to rise, and on the slope of the hill between the 37th and 38th mile-posts,

beds of reddish-gray and purplish-gray sandstone, associated with bright red and gray, sometimes greenish slates, come into view, dipping south-easterly at a high angle; beyond which are broad ledges of gray, very silicious white-weathering sandstones, also dipping southerly, though with some irregularity. The slates are supposed to represent Divisions 2 and 3 of the Cap Rouge section, or Lower Sillery, while the quartzites, which are in two or more bands, separated by belts of slate, are referred to Division 4.

From the 37th mile-post the road, for half a mile, runs on the strike of the sandstones, now dipping north-westerly, beyond which more bright red slates (2-3) appear. The quartzites thus mark an anticlinal, flanked on either side by the red slates. To these succeeds a broad belt of dark gray to black crumpled slates, which occupy the greater part of the space to the church of St. Louis de Ha! Ha! Here another great ridge of white-weathering quartzite comes into view, dipping S. 60° E. $< 50^{\circ}$, while at the base of the ridge on the northern side are found large, loose blocks of limestone-conglomerate, of which the pebbles in some instances resemble corals, but appear to be only concretionary. These are the only rocks met with in the interior which bear any resemblance to the limestone-conglomerates, so strikingly represented on the shores of the St. Lawrence, but the beds from which they were derived could not be discovered, and their precise relations are therefore unknown.

The rocks last described occur in the valley of the Rivière des Savannes, half a mile south of mile-post 34. It may here be remarked that it is at this point that, in the map of Mr. Richardson, the rocks of the Quebec group are represented as followed by the Silurian system, occupying all the area above described; but from the descriptions given it will be evident that the true southern limit of the Cambrian is several miles further south, or about the Cabano River. In the same map the rocks from the 34th to the 26th mile-post are represented as belonging to the Lévis group. As first seen to the north of the 34th mile-post they consist of dark gray, glossy slates and slaty sandstones, which are much corrugated and seamed with white quartz. They rise into very prominent hills, including White Mountain, Mount Paradis and others, and from the summit of these may be seen to form a well marked ridge, extending eastwardly towards the head of Temiscouata Lake. Some of the slates are greenish, others purplish and black, with seams of quartz and chlorite, and their dip, as seen on the northern side of the ridge, is N. 25° , W. $< 70^{\circ}$. Very similar beds have also been observed on the shores of Boundary or Pohenegamook Lake, eighteen miles to the westward, and it is probable that the

Small areas possibly Pre-Cambrian.

ridge is continuous in that direction. In some respects these rocks appear to be older than any seen elsewhere in this section, and recall some of the strata which in southern New Brunswick underlie the lowest Cambrian rocks, as they do also contain other beds which, near St. Magloire, in Quebec, have been similarly referred to a Pre-Cambrian horizon. They cannot, however, here be clearly separated from the undoubted Cambrian strata, and apparently form one series with the latter.

The slates or schists referred to have a width of something over two miles, but owing to the course of the road, which follows the valley of Blue River, occupy most of the space between the 34th and 29th mile-posts. Near the latter the cuttings on the railway are partly through slates of gray, green, purple and black colours, which are very glossy and unctuous, and partly through gray quartzose sandstones and grits, which sometimes become fine conglomerates, and are filled with numerous fragments of black, glossy slates. The latter rocks are in all probability representatives of Division 4 of the Sillery group, and forcibly recall the grits of the latter as seen near the forts in the rear of Lévis.

Fine con-globularites.

Blue River valley.

At the mill on Blue River heavy beds of white-weathering quartzite again come into view, and are seen to inclose thin beds of fine, fissile, glossy slate, while above them are about one hundred feet of black slate, containing thin beds of quartzite, from one to two feet thick, the dip of the whole series being N. 20° W. < 65°. Beds of similar character appear on the slope of the hill south of St. Honoré, and form also conspicuous ridges for several miles, both east and west of the Blue River valley.

Highest land.

The church and settlement of St. Honoré mark the highest point on the traverse from the valley of the St. John to that of the St Lawrence, and have an elevation above the sea level of 1,400 feet. The actual water-shed, however, as indicated by the position of Lake St. Francis, whence the stream of the same name flows to the St. John, is nearly nine miles further west, or is within twelve miles of the St. Lawrence. The country about St. Honoré though high, is comparatively flat, showing only gentle undulations, and is covered with a clayey soil containing but few boulders. Rock exposures are also few, and their character indecisive. Near the southern part of the plateau and settlement are gray white-weathering sandstones, resting on black slates, similar to those in the valley of Blue River; while at the 26th mile-post, are dark gray glossy slates, with a high dip, but much corrugated. These latter have been regarded by Dr. Ells, from their lithological aspect, as being below the quartzites and associated strata, and

Water-shed.

Anticlinal.

as marking a Lower Cambrian anticlinal. It is quite probable that this may be the case, but the exposures, which are only a few yards in extent, are not sufficient to allow of their relations being determined with certainty.

The descent from St. Honoré, on the northern side, is less rapid than upon the southern, and for the most part, the country is less rugged. For three miles and a half from the station there are no exposures, either on the road or railway. Half way between the 23rd and 22nd mile posts, the latter intersects the former, and just beyond the crossing, are cuttings in black, shining flaggy slates, holding thinner bands of green and purple slates. Their dip is distinct, N. 33° W. $< 70^{\circ} - 80^{\circ}$. A quarter of a mile further on is another cutting in dark gray grits, dipping S. 30° E. $< 80^{\circ}$. These latter contain little black grains of quartz, together with fragments of black slate, and are supposed to be a repetition of the rocks already noticed at Blue River, and like the latter to represent Division 4, or the Upper Sillery of the Cap Rouge section. From this point on, for several miles, or as far as the St. Francis River, the railway cuttings are frequent, the prevailing rocks being slates, some of them bright green, purple or red, while others are dark gray to black, and glossy. They include, however, some beds of dark gray grits, and one small ridge of white-weathering sandstone. The dips are, as usual, irregular, but mostly to the southward, varying from S. 30° E. $< 80^{\circ}$ to S. 10° E. $< 90^{\circ}$. They are the strata which, on Richardson's map, are referred to the "Lauzon," forming a portion of a belt extending, with great uniformity, and with an average width of about four miles, all the way from the Chaudière River; but in the classification here followed, are referred to Divisions 2 and 3, of the Sillery group.

Lauzon of
Richardson.

To the above belt succeeds a tract, nearly six miles in width, being the greater part of the space included between the St. Francis and the head of Rivière Verte, in which there are but few exposures, but where such as occur, are very generally of a dark green grit, the characteristic rock of the Sillery, large loose blocks of which are also thickly strewed over the entire area. This belt is also continuous for many miles to the westward, and on the Pohenegamook road, according to Richardson, has a breadth of about eleven miles. To the eastward, its distribution is limited, and in a traverse made by one of the authors by way of Trois Pistoles to Lake Temiscouata, it was found that no continuous belt of these sandstones crossed the line of section.*

Belt of dark
green grit.

To the eastward the nearest section to that of the Temiscouata road is afforded by the road to St. Hubert which leads by St. Epiphane and

*Annual Report, vol. III., pp. 26, 27, 28 M.

Band of Sillery grits terminates.

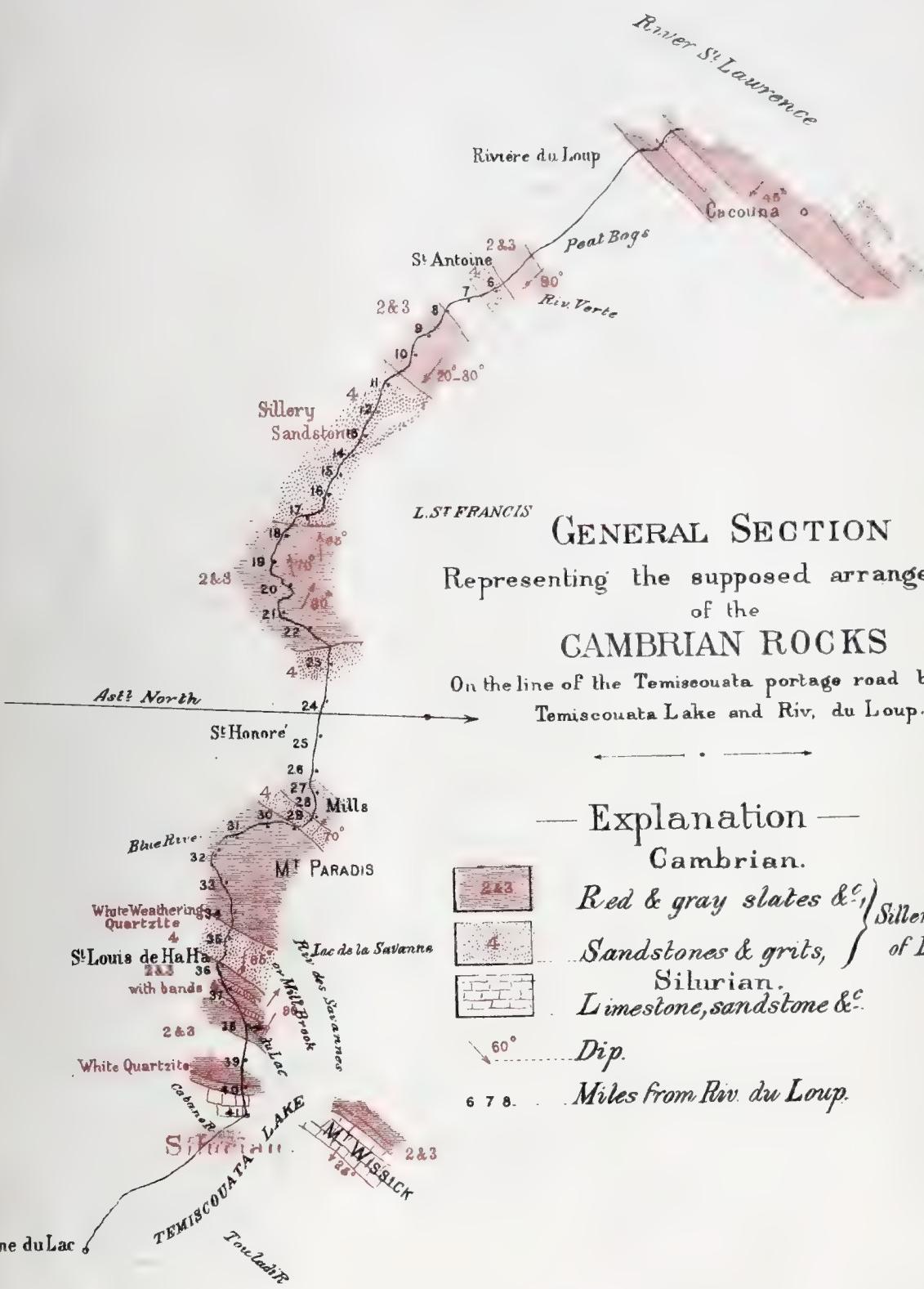
Complexity of general structure.

Thrust faults.

Structure at Mt. Wissick.

St. Francis between which two points, if prolonged on its strike, this band of Sillery grits would pass. Though the distance across to the Temiscouata Road, where the band has a width as already indicated of about six miles and a half, is only ten miles, no trace of this broad band of grits is to be found. It is true that isolated exposures of the greenish grit are seen, but these seem to represent here as over the whole eastern portion of the area under consideration, only lenticular patches inclosed in the prevailing red, green and gray slates. The band, therefore, must rapidly diminish in width as it is followed eastward from the Temiscouata Road, until at a point a little to the east of the eastern end of Lake St. Francis, it entirely disappears as a distinct band and is only represented by the small inclosed areas already alluded to. On several of the roads and streams further to the east good sections across the strata may be seen and in each of these, though the general structure is the same, the details are quite different so that no general division of the strata into well-defined bands is possible. In fact it would be only on a large scale, lithologically coloured map that any divisions could be mapped in the whole complex of rocks stretching from the St. Lawrence southwards to the overlying edge of the Silurian system. In the case of these Sillery sandstones, as seen over the whole of this easterly area the prevalence of southerly dips is noticeable and would seem to indicate that the strata have been effected by a thrust acting from the south-east and buckling up the beds towards the north-west in overturned anticlinal. These overturns form ridges whose steep northerly sides represent in many cases the lines of local thrust faults, the beds having been pushed from the south-east and overlapping by a short slide. A fault on a larger scale, but of similar character to these small local thrusts would explain the structure at Mount Wissick on Lake Temiscouata, where the heavy beds of Silurian sandstone which make up the main body of the mountain, and which hold a fauna indicating for them a Lower Helderberg age, are found overlying at a comparatively low angle the highly contorted and twisted slates of the Sillery and succeeding the steeply inclined beds of conglomerate and shale of Black Point and its vicinity, whose fossils indicate that they are of about Niagara age. A thrust fault of the character above indicated would very well account for this structure, and the moderate dips of the overlying beds contrasted with the almost vertical position of those of Black Point is perhaps to be more easily explained in this way than by supposing that we have here an unconformity between two parts of the Silurian, with an upthrow fault.*

*Cf. Annual Report, vol. III., part II., page 35 M.



These overturn folds with prevailing southerly dips, are very common Structure. in the case of the Sillery sandstones all over the area now being considered, and presumably the slates have been effected in the same manner, though, owing to their being more profoundly crumpled, and often locally bent and twisted, the structure is not so well defined in them as in the more resistant sandstones. The sandstone exposures cannot be traced in continuous belts for any great distance, partially owing to the profound folding to which the strata have been subjected, but more, probably, to the fact that the sandstones have been originally deposited only in lenticular areas alternating with patches of Lenticular areas of sandstone. slates, the sandstones being laid down only where the conditions were favourable for their deposition, these conditions being the same as those which, along the present coast line, cause the alternation of long sandy beaches and extensive mud flats. About twelve or thirteen miles from Rivière du Loup, the band of green Sillery sandstones, last described, is followed by another belt of red, purple and green slates, well exposed near a fall and lumber dam on a branch of the Rivière Verte. They are evidently members of Divisions 2 and 3, being a repetition of the beds at the head of the St. Francis, and mark the northern side of a synclinal, of which the sandstones (Division 4) occupy the centre. The dips, as usual, are southerly, but very variable in their angles sometimes not exceeding 8° or 10° . Half a mile beyond the crossing of the Rivière Verte. Rivière Verte, rocks, similar to the above, occur, but, at the 8th mile-post, are succeeded by black rusty-weathering slates, which are the only rocks visible for over a mile. These, on the map of Mr. Richardson, are represented as the second division of the Potsdam, while to Division 3, of the same group, is referred a series of grits and sandstones which, in the neighbourhood of the 6th and 7th mile-posts, border these slates on their northern side, being well exposed at a mill on another branch of Rivière Verte. We were unable to find any fossils in the slates, but there is certainly nothing about the sandstones which would indicate that they are others than those which, at so many points, form a characteristic member of the Sillery series. They probably mark another anticlinal, similar to those of St. Louis and Blue River, and, as at the latter, are immediately followed northward, at St. Antoine, by another wide belt of (Lauzon) red shales. This is about five miles from Rivière du Loup station, within which distance the country is flat and largely covered with barrens. Anticlinal.

The general arrangement of the rocks along the line of the Temis- Plan. couata Portage, above described, will be better understood by reference to the accompanying plan, in which, however, all minor details are omitted.

Earlier reports.

The rocks about Rivière du Loup have been pretty fully described in the Geology of Canada (1863) and again in Mr. Richardson's report (1867). To these descriptions we have but little to add, except to say that we are quite unable to see any reason for the separation of any of these beds, as Potsdam, from other portions of the Cambrian series. The extremely complicated, not to say unnatural arrangement of the strata caused by the introduction of this designation, with its subdivision into three distinct groups, as made by Mr. Richardson, will be very greatly simplified if only we admit the identity of the sandstones

Frazerville grits probably Sillery.

and grits of Frazerville with those of the Sillery formation, as already described along the Temiscouata section, and as they occur in the vicinity of Lévis. Certainly they cannot be distinguished lithologically from the latter, and their relations to the associated strata would seem to be quite the same.

These, as seen at Rivière du Loup station and at the High Falls, are dark gray green and red shales, with bands of gray quartzose sandstone and gray arenaceous limestone, representing Division 3 or the Upper Cambrian; and the strata of limestones and shales, of similar character and colour which appear at Rivière du Loup Point and along the road to Cacouna, and which were described by Richardson as Division 3 of the Potsdam, are, no doubt, these same beds coming up from beneath the quartzites on their north-west side. Thus the sandstones and grits of Rivière du Loup, or rather of Frazerville, represent another synclinal, and as such extend eastwardly to the mouth of Isle Verte. Outside of the red and gray slate belt which extends through Cacouna to the mouth of the same river, another broad synclinal is represented in the rocks of Cacouna Island. The principal features of difference in the rocks of the Cambrian system as seen along the coast, in comparison with those of the interior, is the occurrence here of limestone conglomerates, interstratified with the red and green shales, and which like the associated limestones, are more or less fossiliferous.

Synclinal.

During the past summers a re-examination of the localities observed by Mr. Richardson, as well as others, have been made by us, but without adding any new information to that obtained by him. The following notes upon this subject and upon the rocks occurring along the coast eastward to St. Fabien are based on observations of Mr. McInnes. As above observed, the rocks which seem most worthy of a special description in connection with the Cambrian of this region are the extensive deposits of limestone conglomerate.

Limestone conglomerate

These conglomerates occupy a comparatively narrow belt along the present coast line. They are nowhere found at any considerable distance inland, but form long ridges parallel to one another and to the trend of the shore. These ridges are often the sides of long

synclinal axes or the crests of anticlinals, and sometimes merely small whale-back areas protruding through the inclosing slates. They can perhaps be best seen about the village of Bic and westerly along the coast between that point and Trois Pistoles. The irregular coast line, so Bic conglomerates. striking a feature along this part of the south shore, and, indeed, the harbour of Bic, are due to the occurrence of these hard conglomerates alternating with the softer Sillery slates. The tides and currents of the river have washed deeply into the soft shales, and left the hard conglomerates projecting in bold points with irregular and striking outlines. A short description of the rocks seen along the shore from Rimouski south-westerly up the coast will perhaps best give an idea of the mode of occurrence of these beds. Occupying the shore all along Coast section. as far as a point about three miles above Sacré Cœur de Jésus are gray slates, cleaved obliquely to the bedding, and showing prominent bandings of red, green and purple. The strike of these slates, though showing considerable local curving and twisting, yet follows one general direction parallel with the coast line, the rocks standing at angles of from 70° to 90° . Above this point the coast is bordered by high bluffs of conglomerate, rising in bold cliffs, often almost perpendicularly from the shore. These conglomerates immediately overlie the slates already described, which still continue to form the flat shore at the base of the cliffs. The cliffs are formed of a coarse conglomerate, which is overlaid by a finer conglomerate and sandstone, which passes upwards into a still finer sandstone or quartzite. This general order of beds is preserved all along the shore the coarse conglomerate, whose nature is calcareous and sandy, and among whose pebbles are many of a tolerably pure limestone, occupying a middle place between the overlying finer conglomerate and sandstone and the variously coloured slates below. These underlying beds are the typical Sillery slates which, at different points along the coast, hold *Obolella pretiosa*, etc.* These conglomerates are remarkable, particularly for the interesting assemblage Variety of pebbles. of pebbles which they contain, which are for the most part of a character quite distinct from any rocks occurring in place anywhere in the neighbourhood. One of the commonly occurring pebbles, often found of very large size, is of a bright gray or drab, fine, even-grained limestone of fair purity—pure enough to have been burned successfully for lime. A limestone very similar to that forming these boulders occurs at Lake Mistassini and about the shores of Hudson's Bay, but as far as our knowledge goes at no point nearer.*

*Annual Report, 1885, p. 32 D.

Fossiliferous pebbles.

Pebbles of a very distinctive limestone, literally crowded with comminuted fossil remains. *Obolella*, *Lingulella*, etc., also occur in considerable numbers. No limestone of a similar character is known nearer at hand than at the Straits of Belleisle, but there beds of so remarkably similar a character are found that it seems probable that the pebbles under consideration have been derived from these beds or rather from a former westerly extension of them.

Diorite and conglomerate pebbles.

There occur also pebbles of a hard amygdaloidal diorite which differs from anything known to occur in the district, and representatives of an older conglomerate, sandstones and quartzites with occasional schists whose derivation does not seem to be so remarkable, though even they are not represented in the neighbourhood by rocks of an exactly similar character.

Derivation of pebbles.

That the beds from which the bulk of these pebbles have been derived nowhere underlie the conglomerates in this district is fairly certain. The complicated folding which has affected all the strata of the region must bring into view at some point representatives of all of the immediately underlying rocks, and beds so conspicuous in their macroscopical character as the two limestones above referred to could hardly have been passed over in a district which is now largely cultivated back nearly to the overlap of the Silurian system.

Absence of Laurentian pebbles.

Another point of interest in reference to these conglomerates in addition to the peculiar assemblage of boulders above referred to, is the absence in them of characteristic Laurentian pebbles. This condition of affairs is in great contrast with the state of things obtaining at the present day. The gravel beds now in process of formation along this part of the St. Lawrence coast are made up in the main from the hard conglomerates and sandstones bordering the shore, but contain in conspicuous numbers, boulders of typical Laurentian gneiss.

Pre-Cambrian conditions.

That none occur in these earlier gravel beds, would go to show that, at the time of their formation, the vast area of Laurentian to the north was covered by other beds. And this view is strengthened by the occurrence of limestone pebbles, already mentioned, which must have been broken from their parent rock at a time when the beds now seen only at Mistassini, Hudson's Bay, and Belleisle, extended widely over the present Laurentian floor.

Early Laurentian floor.

It has been noted by various observers that the Laurentian is found with approximately its present surface contours, wherever the earliest overlying beds are seen overlapping it.*

*Note on the Pre-Palæozoic surface of the Archæan terranes of Canada, by Andrew C. Lawson, Bull. Geol. Soc. of America, vol. I., pp. 163-174.

It had then suffered very considerable denudation even at that early date, and boulders must have been formed in great numbers by the uneven decay of the rock. These boulders should be largely represented in the conglomerates we have been considering, if the Laurentian was then bare of overlying rock, for, from the widely different character of its contained pebbles and boulders, it is to be inferred that this conglomerate was not formed only of material accumulated at the base of some cliff and derived from its decay, but rather has resulted from the gathering together of materials from various beds, probably widely separated. It seems then, probable, that these conglomerates were originally laid down along an extended shore line, defined, approximately, by their present distribution, for the formation of which the materials were carried down from the north by streams and rivers, which cut early Cambrian strata, which covered the present valley of the St. Lawrence and spread widely over the northern area, now denuded down to the bare gneissic hills of Laurentian.

The region between St. Fabien and Bic, and extending back to the edge of the overlying Silurian, is occupied, generally, by strata, which are quite characteristic of the Sillery, as defined in this report. There is one notable exception, however, in the case of a small area of sandstones, which occurs at Lac St. Simon, about five miles back from the coast, the exact age of which has not been determined. The following brief description of these rocks is based partly upon observations by Mr. Ord, in 1878.

To the south-east of Lac St. Simon and forming bluffs of moderate height along its southern shore lies a small, synclinal basin of a rather hard, quartzose, red sandstone which overlies unconformably the red and gray, highly tilted slates and sandstones of the Sillery. The basin is a very shallow one, the rocks dipping, at its western and south-western edges, east and north-east respectively at angles of 15° to 20° and all along its southern edge, north to north-west at the same low angles. The area has a width of only about a mile and a half with a length of three miles and a half. As no fossils have yet been found in the sandstone and as it overlies unconformably, in the form of a shallow synclinal basin, the Sillery formation, the only inference yet possible as to its age is that it is newer than Middle Cambrian.

That it is not Silurian seems also probable as no rocks of a similar character have been found in the Silurian which is well exposed at no great distance where it overlaps the Sillery both to the east and west. Some of the Silurian white sandstone of the basal beds of Mount Wissick are, however, near enough in character to those now under consideration to make it possible that they may represent these beds. The

Temiscouata beds, though they do not show the deep red colour which is characteristic of large portions of these sandstone, often have their generally white colour tinged strongly with pink or light red.

Building stone.

At the time of the building of the Intercolonial Railway this rock was quarried quite extensively for bridge-building purposes and seems to have served admirably this object and it may be considered both from its texture and colour as a building-stone of value. Though an actual contact between these sandstones and the underlying Sillery was nowhere seen by the writer, yet there can be little doubt about the structure. The hard Sillery quartzites which run under the sandstones in east and west trending ridges have a general dip varying from 45° to 90° , while the sandstones themselves in no case show a higher dip than 20° and flatten out from that attitude to horizontal.

Fossils.

The interval between St. Fabien and Bic is especially remarkable for the great development of the limestone conglomerates. The pebbles of these conglomerates contain fossils of Primordial age, especially *Olenellus Thompsoni*, and the associated shales which are of various colours hold obolellas and graptolites, but these latter do not appear to include any Lévis forms, and are regarded as marking a Lower or Upper Cambrian (Sillery) zone. The conglomerates are conspicuously exposed along the railway, between three and four miles west of Bic station and again on either side of the entrance of Bic Harbour, in each case resting on the shales, and themselves covered, at least on the southern side, by beds of white-weathering quartzite. The dips are very irregular and low undulations are sometimes seen, while in addition to the main belts of conglomerate other smaller and lenticular bands occur at various points around Bic Harbour.

Width of Cambrian belt

Near Rimouski the width of the Cambrian belt becomes greatly reduced, the overlapping Silurian approaching on the Rimouski River within a distance of seven miles from the St. Lawrence, and then sweeping around by St. Blondin and the valley of the Neigette to the Grand Metis River. As seen on the road to St. Blondin and at the lower falls of the Rimouski, the rocks are similar to those of Rivière du Loup, consisting chiefly of slates of red and gray colours, sometimes beautifully ribbanded, and holding thin bands of limestone. Similar beds also skirt the shore in front of the town of Rimouski, and thence towards St. Anaclet and Father Point. In this vicinity the width of the Cambrian belt is still quite narrow, the distance from the shore to the Silurian escarpment overlooking the valley of the Neigette on the southern side being not more than eight miles, but a short distance to the west it rapidly widens, and embracing the western extremity of Mount Commis sweeps around to the Rivière

Northern edge of Silurian at Neigette River.

Rouge, a branch of the Metis, near where this is crossed by the Taché road. Mount Commis itself is partly composed of trap (dark gray and purplish epidotic and vesicular diorite) and in part of coarse grits and quartzites resembling those of the Sillery. The latter are a part of a belt which crosses the Rouge and reappears on the Taché road, just west of Ste. Angèle; while both north and south of this sandstone belt are belts of red and green slates, with thin bands of limestone and limestone conglomerate, the characteristic rocks of Division 3. Another wide belt of these Upper Cambrian Sillery sandstones runs south of and parallel to the Neigette River and crosses the Grand Metis not far above where this is crossed by the Intercolonial Railway, being largely used in the construction of the culverts and bridges of the latter. Still farther south, near the mouth of the Grand Metis, are at least two other belts of Sillery sandstone, extending westward in the direction of Ste. Flavie, and separated by parallel belts of very coarse limestone conglomerate and dark gray shales. The breadth of the entire group upon the Grand Metis is about sixteen miles.

The last point to which our examinations upon the coast have extended is that of Little Metis Bay. For several miles from Grand Metis the shore shows only Quaternary deposits and is strewed with Laurentian boulders, mingled with a few of fossiliferous Silurian limestone, but, beyond this point, gray shales, banded with purple, come into view, and may be followed for a considerable distance, their general dip being southerly at high angles. Approaching the Light-house heavy beds of gray sandstone come into view, often with reversed dips, and run out to the promontory on which the Light-house stands. From this point to the mouth of the Little Metis the trend of the shore is nearly at right angles to that of the measures, and hence a section is revealed which is one of the most complete to be met with anywhere along the coast. It is also very interesting as containing the beds in which the remains of fossil sponges were found by Dr. Harrington in 1887, and subsequently more fully collected and determined by Sir William Dawson. As the section, with its Fossils. contained organic remains (including, besides the several species of sponges, shells of *Obolella pretiosa*, Billings, fucoids of the genus *Buthotrephis*) and (in the sandstones, *Astropolithon*, *Retiolites* and *Arenicolites*) has been very fully described by the last named author in the Transactions of the Royal Society and elsewhere, it is not considered necessary to reproduce the details here. It may, however, be said in general that both the aspect and the arrangement of the rocks, which include limestone conglomerates, shales and sandstones, are

Little Metis
Bay Quater-
nary deposits.

Probable age. much like those of the beds at Grand Metis and again at Bic, and probably occupy about the same horizon.

Railway cuttings examined.

Little Metis.

Berniers to St. Moïse.

St. Moïse to Sayabec.

In the rear of the district last noticed, and about the sources of the Little Metis River, the Cambrian area is traversed by the Intercolonial Railway; and between Little Metis Station and that of Saint Moïse, long and deep cuttings have been made. Unfortunately for their present examination the greater part of these are covered with snow-sheds which almost completely exclude the light, and a satisfactory examination of them is difficult. The longest cutting, exceeding a mile, occurs at and just south of Little Metis Station, and is chiefly in dark gray slates, dipping southerly. A quarter of a mile further south another cutting shows gray glossy slates and shales exhibiting several archings, but also for the most part dipping southerly. The next long cutting is also in shales, mostly gray, but including others of purple colour. Still another shows purplish red shales, often splintery and with alternating beds of gray, the whole lying in a succession of low folds. To these succeeds a band of coarse gray grit containing numerous pebbles of white quartz, mingled with many of black slate, and which no doubt, represent the Sillery sandstones of Division 4, the beds previously mentioned being those of Divisions 2 and 3. The dip of the sandstones is northerly, and on their southern side they are immediately underlaid by bright red slates, showing beautiful archings. A quarter of a mile further south more bright red slates occur, alternating with coarse gray grits, and showing great irregularity of attitude, and then after a similar distance a long cutting in dark gray to black slates and shales, probably a repetition of those at Little Metis Station. This cutting is about one mile north of Berniers, within which interval there are no exposures; but south of Berniers, which is five miles south of Little Metis, and thence to St. Moïse, bright red beds again predominate, mingled with others of gray and dark gray tints.

Between St. Moïse and Sayabec the Cambrian is unconformably overlapped by the Silurian and the area examined by us meets that of the Gaspé region explored and mapped by Dr. Ells.



